Bill

Notbook #1

Index for cooked Canada Balsam = 1.537 according to Rogers & Kerr. Raw balsam = 1.525-26.

[illegible]

NOTES ON FUNAFUTI
AND BIKINI
CORES
&
THIN SECTIONS
AND OTHER NOTES

Gordon G. Lill

Notebook 21

FUNAFUTI

0-10 ft.

slide No CORE No.

501

502

Not received in shipment

2 3/32" X 1 3/32" plate size. made from core #1.

Main bore 0-10 ft. solution channel present in slide. Material adjacent to channel is brown in color (altered in some manner)

amber colored material deposited along solution channel and in borings & interstices. Opaque, shows partial extinction, high relief, granular surface much like clay minerals halloysite or nontronite. Birefringence high, mottled interference colors of 3rd order green, orange & blue. I.R. higher than balsam. (Becke-line method). Impossible obtain Interference Figure.

Brown, altered zone shows parts with woody structure Believe alteration due to humic-acid from roots. (Hand specimen shows roots present). encrusting forams

Have heard somewhere that plant acids facilitate processes of base exchange and formation of clay materials. Amber material could be a clay but I do not know where enough silica could come from to form it. Perhaps from sea-water.

This may be collophane

Slide
No

CORE
No

502 cont'd

Some secondary calcite present in interstices in ~~early~~ stages of crystallization. (aragonite?)
Aragonite usually appears as finer and more needle-like crystals. Calcite is stubbier.

2 Hand specimen - $3\frac{3}{32}$ " dia. - $4\frac{10}{32}$ " long. *Helispora* present with original blue-gray color. Mossy grey in color speckled with pink (*Polytrema*) and brown forams. Porous. Some interstices filled with white chalky material. Fizzes in 5% HCL. Some organic (woody) material present in porous spaces.

503
(0-10')

Oolites present in considerable quantity. Show following structure

Circular type

elongate type

extinction looks like isogyres of uniaxial interference figure forms false cross.

elongate type may be corals or some other animal.

(See page 188. Hinde reports no true oolitic material present in *Funduti* material.)

These are
lobophyllum
spicules
and not
oolites

Slide
No

CORE
No

504
(0-10')

Yellow mineral. Parallel extinction. Yellow-green interference color (third order). These do not fit *Collophane*, but I can't find any other yellow-brown mineral that fits. Rogers & Kern state that *Collophane* is generally ~~rep~~ formed by the replacement of original calcareous organisms.

505
(0-10')

see book. Same. Slides 604-606 and 607 all same as above slides

506
(10-20')

13

Large slide ($4\frac{1}{2} \times 6$ ") No comment on slide. Book says it is *Madrepora contracta*. No comment on hand specimen. Slide in excellent condition. No cover glass was used on these large slides. Balsam well preserved, no age cracks.

507
(10-20')

13

Small section of above coral. No comment. Some brown (*Collophane*?) material present in porous spaces in minor amounts.

Slides 608-609-610 also listed here. 608 and 609 are long narrow sections of coral (no comment) slide 610 shows encrusting forams and lithothamnium (no comment) Hand specimen #16 applies to slide 610 (no comment)

(10-20') 21 to 32

Slides 611-612-613-614-615 and 627 all apply here. No comment. Cross sections of *Leptoclinium* (?) give nice negative uniaxial cross with many color rings (Calcite).

Slide	Core	FUNAFUTI
513	83	at 68 ft (60'-70')
622	68	Brown unidentified mineral present. Madrepore
623	65	sections for most part with encrusting forams and algae. Part of interspaces are filled with unidentified material called "sclerenchyma" by Funafuti authors. I do not know how they determined this. Some minor secondary crystalline growth in interspaces (622).

	(70-80')	note zone of alteration around tunnels of boring organisms. @ brown. Tunnels are perfectly round in x sect.
624	85-87	Septa walls of coral (Madrepore) appear to be somewhat disintegrated where cells are filled with aragonite xls.
625	88	Much less better shape when no cell filling of any sort is present. ^{This also shows in color change} Brown mineral still present from light brown to dark brown almost black. Forams appear to be unaltered, however could not find calcarina
626	89	
627	91-92	

secondary xls. not numerous in either section

64 to 74.5

Slide	BIKINI
2-4-2	Unidentified brown mineral present in these slides too. Tracy thinks it is made up of tiny calcite needles, almost sphyrocrystalline.
2-4-3	Brown color may be due to Fe, P, Mn, etc in very small quantities, and that apparent outline of crystal needles is caused by the becke line phenomena. Some very secondary xl growth in the interspaces probably calcite needles. More xl growth present and more brown material in this section than at same depth in Funafuti material. Can see no evidence that brown material is an alteration product of calcite since it seems merely to fill cavities with well defined boundaries. Cavities also filled partially with mud (?) in this section.
2-4-4	
2-4-4A	
2-4-5 (2)	
2-4-5 (1)	
2-4-6	

74.5-75.5'	Some secondary xls in interspaces. Brown mineral present.
2-5-1	corals seem to be x lym. Some interspaces filled with mud.
2-5-2	Some forams appear to be altered or somewhat disintegrated
2-5-8	others have nice sharp boundaries with the surrounding calcite. Calcarina seems to be the forams that is slightly altered
2-5-10	around edges. Had not noticed this in previous slides. Coral septae walls do not appear to be much altered, where secondary xl growth is present.
2-5-12	
2-5-13	

8
Slide core
80-90'

FUNAFUTI

514 96
515 100

well x lined. ^{dry} Calcite beginning to appear in the cavities toward the center, aragonite still present toward the outside of the cavity. Slide 515 shows much more secondary calcite in interspaces. Forams appear more disintegrated. Aragonite not noted in these slides

90-100'

630 105

Scalenohedral calcite appears lining cavities as a crust

100-110'

516 } 110
517 }
518 111
519 114

coral (Astrea) 518 filled with calcite rhombs or lined with tiny xls. Coral in fairly well preserved state. Apparently both Aragonite and calcite are present.

BIKINI

9

95.5-116'

2-6-5
make photo

Shows secondary calcite also, but not so well developed as corresponding section from Funafuti. First slide to show well developed calcite rhombs.

Forams appear to be altered. Unable to detect aragonite altho probably present

incipient secondary calcite xls.
Calcite
showing solution or alteration area around cavity indicating that xls. are re-deposited from material dissolved from cavity walls.

See above

See above

110'-120'

631 117

Madrepora interspaces empty for most part although some are filled with detritus or xls.

120'-130'

632 123

633 124

Pocillopora (632) fair state of preservation largest secondary xls. yet observed in Funafuti section. Apparently not mentioned in text. Cavities partially filled with these long xls and also with rhombs. Wall along which xls grew shows considerable effects of alteration. (633) does not show same large xls. although some interspaces are filled with very fine xls. there are still about $\frac{3}{4}$ which are empty.

116-137'

2-7-2

See above

634

132

635

133

Photo?

(635) interspaces almost all filled with x-ylm. calcite. No crystals present that appear to be aragonite. Dark, muddy material in some of the cavities. Coral (*Madrepora*) structure in fair condition. One cavity noted with two types of cavity filling present

MUD

the calcite crystals extinction direction is at right angles to extinction direction of the center filling which is definitely calcite. (This cavity located in extreme upper left hand corner of slide.) There are also other cavities which show this. Slide also shows definite alteration of cavity walls grading toward center of cavity to well developed x-ylm calcite. Small xyls at edge next to altered zone.

140-150'

636

135

637

136

638

137

Handy any infilling of calcite in these corals. such xyls as present all seem to be growing on one side of the septa in slide 637. ? is this the upper side?

most all cavities empty. coral in good shape.

137-158'

2-8-7

2-8-7 from same general depth as Funafuti shows same muddy material but ^{minor} center filling of calcite. Tiny xyls. grow around edges of cavities next to zone of alteration. Coral is crystalline has same appearance as Funafuti slide 635 at same general depth. Unusual of the brown mineral noted. Not seen in slide 635 from Funafuti.

fish says note worm hole →

← muddy disintegrated zone
← brown mineral zone around lower worm hole
x-ylm. calcite infilling center of worm hole

Every worm hole I have seen so far has brown altered ring around it. This in both Funafuti and Bikini cores. Even noticeable in Bikini hand specimen. Believe this to be due to acid solution secreted by worm in order to help bore its way thru the CaCO_3 rock. This causes a chemical change in the rock and resultant brown color. Note now that much of the brown mineral in this slide is shot through with round bore holes. I must find out what kind of acid these worms secrete.

See above

520

521

141

522

full of foraminifera and slyd calcite.
 520-521 large slides difficult to tell much.
 shell fragments and detritus of one form or another.

160'-170'

 849
 Photo

143

fragment slide. Calcite fragments, forams. Funafuti
 report states that organisms have lost their fresh appearance

158-169'

Get Photo of 2-9-8

2-9-3

2-9-8

2-9-16

2-9-22

2-9-23

2-9-3 *Homotrypa micracum* encrusting coral. Cavities mostly empty.
 Some beginnings of secondary calcite. Minute quantities of mud in cavities.
 2-9-8 Cavities half full of mud in coral upright position. Two kinds of
 mud, in one cavity dark, dense mud on top of light, less dense mud. Some brown
 mineral noted with worm holes. 2-9-16 fresh cup due not worm holes but likely one-
 celled animals of some sort. Some blue-black opaque mineral noted probably MnO₂ men-
 tioned by Tracy, perhaps carbonate mineral. 2-9-22 Some mud filling cavities, some
 secondary calcite. Coral seems to be well slyd calcite. ²⁻⁹⁻²¹ Crystallization of mud beginning in
 some of the cavity fillings. Noticed also in 2-9-8. Alteration of coral walls around mud filling is
 noticeable. Considerable brown mineral present in the mud fillings. Spicules present in all the mud.
 Some cavities empty, some merely lined with mud. 2-9-22 Lots of brown mineral present, most
 of it is in shell fragments (weathering?). Heterogeneous mass of broken shell fragments, even
 some of the forams are in bad shape. fragments all angular and roughly broken. This slide
 quite different in appearance from preceding slides. Was it at surface? ^{spicules in the} mud fillings

 shell filling mud
 158-169'

→ see notes above also for statements that fit with this.

Martin should check ecology and types of organisms
 at between 160-170 ft.

170'-180'

523

524

639

144

fragmented material, mud filled; some cavities show a beautiful lining of calcite with stubby crystals. Echinoid spines numerous
Mud partially infills some of the cavities. Brown material present.
640 shows considerable calcite recrystallization as does 641.

640

145

641

Photo 146

Calcite secondary crystallization seems to be heavier in these slides. Fonafuti report says fossils are beginning to lose their fresh appearance here. This is noticeable in slide 641. But photo to show heavy recrystallization and loss of fresh appearance of forams.

523, 524 and

But note that report says of slide 639 "foraminifera ... are in good preservation and their minute structure is distinctly shown under microscope"

MUD

180'-190'

Photo

642

151

643

158

recrystallized calcite fills cavities. Fonafuti report states that casts appear at this depth for the first time, also that fine white powdery material appears in the interstices for the first time. Globigerina noted in slides. Marginopora also noted but was not reported in Fonafuti report.

There may be a break here. Check cores

NOTE:

Make new slides and cut pieces for analysis from cores NE 144 through 158.

note that Marginopora in Sublittoral zone
Fonafuti report
Carpenteria
marginopora is
unfound.

Chalky material is found in both sections at this depth as well as globigerina which appears to be more abundant at this depth than Heteropora. (See if Martine will check this)

See below also

179-190

Globigerina, Gastropods noted in this slide. also Amphistegina seems to be in disintegrated condition. Heteropora Amphistegina was holding its original structure very well. Majority of the material in this slide is brown in color. Everything except the tiniest forams is fragmented and angular. Material in this slide is cemented with calcite, but cementation is not as striking as in ^{slide} 642-643 of Fonafuti core. Everything interstices in coral are filled with mud. little brown seeds present. Sphenulites present.

Check cores, drilling log

Make new (or more) slides from 10th and 11th core runs.

190-200'

525 } 159
 526 }
 644 } 166

secondary crystals noted in cavities here in very minor quantity and tiny small inclusions. Heavy crystallization noted in preceding two sections not seen here. Some of the echinoid spines have lost structure completely while others still show a semblance of structure. Brown mineral noted as in-filling in some of the cavities.

200'-210'

527 } 176
 645 } 178

secondary crystallization only minor in cavities slide 527 in doubt as a contaminant in Funafuti report. Slide 645 shows better crystallization and larger crystals than any seen since 170-180' ft section. Amphistegina now still shows some alteration. Small well altered part of structure replaced by calcite shombs. Calcite crystals in interstices are in one layer only.

5 calcite aciculus

shows very fine checkered pattern
 is it algae? shows 11 extinction
 may be an add section through
 echinoid stem

? m.p.

little brown seeds present but rare

192-200.5

2A-12-4

2A-12-7

2A-12-15

Very fine fragmented angular material merely brown in color. Has same general color appearance as shown in Funafuti section at this depth. Every fossil seen in slide 2A-12-4 is fragmented. Globigerina appear abundant. Echinoid spines completely recrystallized as seen by uniform extinction instead of several flame frequent extinction shown by original structure. Material cemented some by calcite matrix but it is still rather porous. Numerous of the little round brown things that I thought might be worm tubes, could these be plant seeds of some kind? they are exceptionally abundant.

what? triangular x section of tiny gastropod? Foram? m.
 calcite

sphurilitic present ⊕ extinction pattern

200.5'-211'

2A-13-3

Slide very similar to above slide fragmented, somewhat cemented by calcite. Globigerina, marginopora, amphistegina all brown in color. Amphistegina losing most of their structure and turning completely to calcite in a few instances. Crystal growth in cavities is minor. Marginopora noted undergoing cell division ⊕? noted again, no internal structure visible. no little brown seeds noted in this slide. Fine sphurilitic abundant ⊕

210'-220'

646 180

646-647-648 mottled black, gray, brown. fragments, fossils, CaCO_3 grains.

647 181

Fossils - Amphistegina, brown red, *Literostegina*, *Globigenerina*, *Homotrypa*, coral, echinoid

648 183

spines, whole, altered, structure still visible, most all light brown in color. fossil cavities almost filled with calcite in *Globigenerina* in coral lined or filled with calcite some cavities in coral 647 almost empty. Calcite present as cement and as stubby crystals in some of the cavities, well cemented, encrustations heavy type cavities abundant about 50% holes, opaque, dark grains (white in reflected light) angular to sub-rounded appears to be a coating on calcite (oxide). Spherulites present, angular fragments fairly abundant. Only one cavity noted 647 under mud or detrital filling.

835 185
836

Sample of loose material. Angular to sub-round. calcite grains, fossil fragments, grains have oxide coating dark in transmitted light, white in reflected light. CaCO_3 grains that are obviously secondary show no oxide coating.

But slides above 220 and below 220 for calcite aragonite tests

220'-230'

528

All slides have mottled black, gray brown appearance. appear to me to be cemented fragmentary material and fossils. Some fossils broken, none disintegrated.

529 186

Fossils - Amphistegina altered, echinoid spines, no coral noted in slide.

530

Spherulites present 2 noted in four slides. Cavities either empty

649

or completely or partially filled with calcite, some cavities show calcite encrustations. No mud found in cavities.

More fossils present than they name in the book. this has been generally the impression I get throughout these slides

211'-221.5'

Section a mottled gray, black, brown. Mostly a piece of coral with some filling material. Coral structure shown unbroken but altered to calcite completely. Part of coral cavities filled with

2A-14-2

muddy detritus, part with calcite stubby crystals and part solid secondary calcite.

Amphistegina (rare), globigerina (rare), marginopora, forams unidentified, x-section

cavities in forams empty, forams mostly entire, little altered in shape, structure undoubtedly gone to calcite. Calcite crystallization fairly heavy both as solid calcite and as crystal lining in cavities. fairly well cemented sample although not very hard probably. Detritus present is very fine grained calcitic mud part of which is turning to xylm calcite. No spherulites or little brown seed-like objects noted. Cavities make up about 40% this section, rest is calcite.

But slides under 220 and above 220 for calcite - aragonite tests
Funafuti report says no aragonite at all in this below 220' in this section.

230'-240'

850

No solid cores obtained from this 10 ft.
 850 is slide of fragments which are angular and coated with an oxide. Amphistegina, echinoid spine fragment and one other foram all to be noted here. fragments angular to subangular. Calcite encrustations around the forams indicate they came from at least a partially cemented material.

240'-280'

650

837

838

839

} fragment
 slides

total core here 1 inch in 40 ft. slide 650 shows mottled gray, black brown material in matrix of cemented calcite. fossils (mainly forams) both altered and fragmented. foram cavities filled with calcite. Cavities in whole thin section make up very small percentage (less than 5%) of slide. cavities empty but lined with stubby calcite x yls. or dark oxide lining of some sort. No spherulites or brown seed like objects apparent
 Would say this section was cemented but soft and very difficult to core

24

EUNAFUTI

280-330'

No core obtained in 50 ft.

841

330-373

No core obtained in 43 ft.

BIKINI

25

26

373-378'

531 204

652 205

531

532 } missing

532A)

Condon
(532, 532A)
and 532 are
not missing
(Russell)

check Rotalia

calcar and Foram

assemblages

also 5' drilling break

378-410'

FUNAFUTI

531 most of fossils brown in color, with mud, canaliculi etc. slide presents a mottled appearance of brown, gray, black. some fragmented material. Fossils - forams look whole except in few instances, original structure preserved in forams but apparently recrystallized. Corals structure difficult to determine, fossils light brown in color, fossil cavities infilled with calcite. Amphistegina the most abundant, ^{encrusting forams present} marginopora present, globigina present but not abundant (rare?). Calcite present as both crystals, encrustations and solid cavity fillings showing good cleavage. Crystals are stubby type. Cavities are mostly infilled with solid calcite, some with calcitic mud. Globigina in this section are of different type than those previously seen above before they looked like this. OB in this section they look like this? Phenolites present but quite rare. Some of the detrital material angular to subangular but mostly very fine. Porosity (cavities) abundance about same as before.

Rotalia calcar suddenly appears I think, but not in abundance. Note also drilling break above and very small core

no core in 32 ft. Funafuti report states that sand etc. obtained from hole appeared to be cemented by calcite. Gastropod casts, amphistegina, calcarina, porites, orbitolites, carinata, lithothamnion reported.

BIKINI

27

410-420'

653

207

654

212

845

lenticular 653-654 brown, black gray mottled appearance, fossils, fossil fragments, detritus cemented by calcite. 845 fragment slide apparently same thing. ^{most abundant} ~~Fossils~~ Amphitegma, calcarina, zygospira, encrusting forams all present. Some are entire some broken and fragmented. fossil cavities filled with calcite. foram structure quite good still. spicules looking in x sect much like sphenulites. abundant in 654. Extinction pattern different for what I call sphenulites. all fossils light brown in color. Calcite fills the cavities mostly solidly. Some crystals noted in cavities but not very abundant. Calcite present as solid cement and as xyls. Cavities filled solidly with calcite for most part although some ~~are open and~~ ^{are open and} lined with xyls. No cavities noted that are filled with mud. Not any detritus present except fossil fragments. No sphenulites noted. No brown mineral noted. No globigulina noted and none reported in Funafuti report.

420-450'

No solid core 420-430' 430-433' solid core 3" H. solid 1' 6" measured

655

214

222

655 almost entirely calcarina cemented with calcite and detritus of same sort. Slide brown gray, black mottled appearance. ^{Rotalia calcar} Calcarina hispida very abundant mostly well preserved structure and brown in color. calcarina cavities filled with calcite solidly. Calcite present as cement or very minor incrustations in cavity walls. Some of the cavities filled, or partially filled with fine detrital mud which has become partially xylized. ^{abundance} ~~abundance~~ ^{Rotalia calcar} ~~abundance~~ ^{may be significant here.}

There may be a break here between 373-450 someplace corresponding to break at 177-220 at Bikini.

Mud

see 373-376'

check

Rotalia calcar
abundant, mud in
cavities, drilling
breaks & solid
Lithothamnium in next
section below.

450-457'

656 226

846 fragments

533 229

534 missing

(534 not

MISSING

(MR)

slide dark in appearance. Mostly solid lithothamnium and encrusting forams. this may be of significance coming in just below abundant

Rotalia calcar - Fossils - encrusting forams, lithothamnium. Fossils which were formerly abundant do not appear at all in these three slides (ie) Amphistegina

Rotalia calcar, etc. ^{also reported in book} Calcite fills some cavities, calcite xyls. more abundant and better developed than in section immediately above this may imply water circulation. Cavities filled with calcite, lined with calcite xyls. or partially filled with detrital mud again. Detritus organic remains and very fine sediment. No spherulites noted. Brown mineral appears again but no light brown seeds.

Is this a foram? its very large if so. Completely infilled with xylm calcite. see slide 533

second look at 846 shows some amphistegina (hole)

457-468'

657 230

658 233

657-658 fine detrital mud with some fragments fossils. Amphistegina fragments reported in Funafuti report. None noted by me. Forams missing here again I'd say. xylm calcite cements the mud somewhat. xyls. in cavities nil, but some minor encrustation of calcite appears on cavity walls under x & nicols. Cavities appear to be partially filled again with mud showing flat bottoms and rounded or angular tops. This detrital section may be important. some brown mineral noted

Do not concern M.R. Rare perhaps but not lacking.

468-480'

659 236

6" core
~~No core~~ 7' bored. ~~No bits~~
 Funafuti report reports no organisms other than
 a chance alcyonarian spicule. ^{echinoid spines} Essentially the same as
 the above 11 ft. very fine detrital material. Cavities quite small.
 Cemented by calcite? No calcite xgls. present. If forams (forams) were
 present (and corals) here and above they have nearly all disappeared.
 Echinoid stem x section about all I can identify.

480-487'

No core. Only organism seen in broken material was
 chance alcyonarian spicule according to Funafuti report
Fine detritus here again, I presume

487-497'

660 240

thin
 section missing. Funafuti report says calc. sediment cemented
 by calcite. Fossil assemblage reported is small

497-505'

661

243

Sediment mottled gray, brown appearance. Fossils - *Marginozoum*, echinoid
Carpenteria spines abundant; Calcite present as cement or encrustations lining
 cavity walls. Some minute xyls present. Cavities mostly empty. A few
 partially filled with calcite. Detrital material too fine to determine
 grain angularity. *Amphistegina* still not present after getting
 out above. *Rotalia color* has not shown up again since
 450 ft. Brown mineral present. No brown seeds present.

505-517'

662

255

663

258

Brown grey mottled thin sections. *Amphistegina* has returned in some
 abundance again although much altered and somewhat fragmented.
 Fossils still brown in color. Some *rotalia*? has again, I think. Spines,
 fossil fragments etc. Calcite present as cement and as scalenohedral xyl
 in cavities in good abundance. Some cavities filled with mud,
 some calcite and others merely lined. Encrusting foram (*Polythema*)
 very much fragmented. No brown mineral, no weed seeds, no
 spherulites, no mud in cavities but I suspect that because
 of the dirty appearance of the calcite that it was once mud.
 Most unusual condition noted in these two thin sections is
 the condition of the forams.

Much altered
 appearance of forams
 quite striking here es-
 pecially after their
 initial disappearance
 for awhile

517-526'

664

263

535

267

thin sects, mottled gray-black-brown. Fossils - Amphistegina, rotalia?
 Gypsina, polythema minacium etc (see book), abundance forams has
 dropped somewhat. Forams still broken and old looking (worn), fossil cavities
 filled with calcite. Calcite present as cement and heavy stubby xyls in some
 cavities. Cavities filled solid with calcite or lined with heavy xyl
 encrustations. Some of the calcite is solid ~~###~~ showing good cl.
 most is grainy ~~###~~. Some cavities still have detritus, mud? in them.
 No spherulites, weed seeds, or brown mineral noted.

Echinoid stems surrounded by solid calcite believe stems were altered
 look like this - solid calcite

Note good core recovery 4 ft out of 20' ↓

526-546'

665

269

666

274

667

284

Slides present mottled appearance. Consist of coral, lithothamnium and
 polythema filled in with detritus, mud, forams and xyl calcite
 both as cement (granular) and xyls in the cavities. Coral cavities partly
 filled with mud and upper half with xyl. Calcite not as xyls. but
 granular type. Some calcite xyls present in places. Some rare pieces
 of brown mineral. No spherulites noted, rare weed seed noted.
 Amphistegina, etc no rotalia noted, no marginopora noted
 since 505 ft. The amount of mud in cavities seems to be greater
 here than usual.

Mud

546-555'

536 294

668 294

669 296

Sections show brown-gray appearance. Lithothamnion and Carpenteria most abundant, other forams scarce, noted one disintegrated marginopora, one questionable rotalia, one or two amphistegina. Spaces between lithothamnion and polythema filled in with detritus and mud most of which has not yet become xylized. Calcite present in xyle and in granular form neither of these forms as abundant as the mud. It is striking to note that spaces inside the polythema are all filled with mud.

showing minute detail of mud filling in Carpenteria.

555-567'

No Core in 12 ft.

847 fragment
test

Funafuti report lists various foram pieces in this slide. I can see calcite pieces, questionable corals, rotalia, amphistegina and that's about all except questionable heterostegina.

567'-578'

670

296a

671

296b

Slides give mottled appearance. Forams again abundant. Amphistegina, heterostegina, rotalia, encrusting types, and Cycloclypeus which makes its first appearance. All these forams in detrital material. They appear altered ^{and} ~~but~~ otherwise in ~~good~~ ^{poor} structural shape. Some mud but cavities for most part filled with granular calcite.

Cycloclypeus appears

cycloclypeus cell division?

670

cycloclypeus slide 671

These one should be carefully identified and some further thin sections made from 296a and b

578'-598'

537

304

538 missing

(538 missing
not missing
MR)

Detrital material filled with forams. Amphistegina-abundant rotalia-few, cyclopus-one noted some fragments, encrusting forams. Calcite cements detrital material and forms minor encrustations in cavities, no xyls noted. 1 large Amphistegina? noted 3.2 mm

I can identify globigerina but the other forams mentioned I cannot pick out (ie) Discolina, Bolivina etc.

No brown mineral, no spherulites, calcite present is granular

598-612'

sections 672 and 674 detrital and forams. Forams not very abundant. Report mentions several forms. Marginopora and cycloclypens not seen nor mentioned. Cavities mostly empty or inner wall lined with minor encrustations of calcite. A few cavities formed by dissolved Halimeda leaves, one of these holes was filled with calcite but most were empty. Halimeda molds were not numerous. No brown mineral, spherulites noted. Calcite xls very few.

Slide 673: have most interstices filled with x-line calcite

612'-624'

No core obtained in 12 ft.

624'-637'

Sections show detrital material but well sorted to calcite.

675 307-308

539

540

309

missing

Most cavities open, no mud apparent but cavities lined with encrustations (minor) of calcite. These sections appear to be much more substantially cemented than any looked at hitherto.

I can't seem to identify many of the forams noted in the Funafuti Report. Forams do not appear to be abundant in any case.

No brown mineral, weed seeds or spherulites noted. Cycloclypens, marginopora rotalia not noted.

44

no = Still is not missing - The Tunaputi Dolomite

639'-643'

541

313 missing

542

316

543

missing

544

318

545

320

546

320 missing

676-677

314

Dolomite comes inhereSee about various
other checks - here
here.

Well cemented detrital material. Cement changing from calcite to dolomite between core 313 and 314. Cavities open for most part but in slide 545 many of them are filled with opaque mud. This rock seems to be much better crystallized than any ~~seen to date~~ ^{inspected} down to this depth. This higher degree of xylgn. began in section immediately above. Tunaputi report states that the large part of these cores consist of forams. If these slides are any criteria, I do not agree. Forams are not abundant.

The big change

643'-652'

547

325
not m. (MP)

548

missing

678

328

679

328

549

329

550

331

551

332

552

333

553

334

554

555

335

missing
not
MP.

Forams not abundant in this section until depth of slide 552 is reached, here Amphitegma etc again becomes abundant. Cavities lined with dolomite encrustations I presume. Many of the cavities are empty, none seem to be completely filled and some partially filled with detrital material.

No brown mineral noted. Some fossil fragments looked like Cyclopyrenus but could not be sure. Report does not mention Cyclopyrenus.

Sikini

45

652-660'

556 336

557 337

558 } 338

559 }

680 339

560 340

561 } 341

562 }

563 }

564a 342

564 343

Seems open to be, only cemented, highly abundant forams and algae + encrusting forams. Cyclopyrus and Marginopora appear here again. Pores forams are frequent. Heterostegina very abundant as well as Amphistegina. Cavities encrusted with dolomite ryl. Dolomite cement very finely granular. Many of the cavities in this section seem to be filled with something, just encrusted on inside. The spherulites are sparsely noted.

2" Rock hard to soft
partly cemented and
coral? - quite porous

3" Debris and
Forams (Heterostegina-Amphistegina)
Lithothamnion and Homotrema
#557 typical rock section here.

660-670'

565 344

565a 345

(millimetric)
Section 3
in 2

fine particles, dolomite rock. Much forams and debris. Funafuti report described as soft and chalky. Cyclopyrus and Heterostegina abundant. The disc-like forams all seem to be aligned. Some are turned crossways. Small cavities are present, but are not filled, they seem to be lined with very minor encrustation of dolomite ryl (Alperine).

A sedimentary (Heterostegina bank) is likely at 652 ft.
? why

Funafuti670'-691'

567 348

568 349

570 351

571 352

572 354

573 355

indurified this section appears to be porous, soft, granular appearing dolomitic rock. White in color. Funafuti report states it is soft and friable. Forams - *Homotrypa*, *Litostegina*, *Cycloclippus*, *Amphistegina*, ^{gibberulines} large forams fragmented but aligned with long axis $\perp$ to core length. Cavities empty. no xyls. minor encrustation on inner walls.

691'-698'

574 357

575 358

576 359

577 361

578 363

579 364

580 } 365

581 } 366

582 }

Section same as that above. *Cycloclippus*, *Litostegina*, *Amphistegina* etc. abundant. cavities empty. No xyls. soft, friable, etc.
Examined cores 357 and 366 they are very soft and dead white.

Bikini

698'-706'

681

2A

Funafuti report states rock slightly harder here. It appears same as above to me. Cavities are still voids with only minor encrustation of xyls on inner wall although perhaps somewhat heavier than in preceding slides. Halimeda abundant here as above.

Large forams here that looks suspicious to me

get new thin section here

706'-716'

682

4A

683

8A

In thin section the rock here appears to be more dense than preceding with less porous space. Those cavities present are still voids and no xyls are present. Report states this still soft rock.

716'-736'

684 11A

685 14A-15A

686 16A

Sections same as above. Cycloclypens abundant. Cavities void except for very minor encrustations. Rock still white, soft and porous. This section more porous than that immediately above.

685.- Cycloclypens reticulatus ? *new slides made*

736'-748'

687 21A

688 22A

689 25A

690 28A

This section same as above in upper part. Lower part more dense and shows some very tiny xyls. also partial ^{detrital to dolomite} mud filling of the cavities. Forams exceedingly abundant in slides 689-690. Report states lower part this section drilled harder. Also report states cycloclypens not noted here in lower part. I could not be sure of this but I noted ~~not~~ no certain cycloclypens.

748-763

(5838)

691 36A

692 37A

693 } 40A

694 }

695 42A

696 45A

697 47A

698 49A

699 } 51A

700 }

701 52A

702 54A

Porous white dolomitic (granular) rock. Cavities only partly filled with consolidated (xylid mud) slide 694 shows this excellently. Cavities also filled with brown mineral. Could this be a hydrocarbon stain? Marginopora numerous in this section, Cyclopyrene, rotalia? Amphistegina etc present. Dolomite seems to be granular type. Small xyls. line many of the cavities and interspaces. They are not heavy encrustation but are well defined and more pronounced than in section above. No spherulites or unusual objects noted.

MUD

763-771'

584 59A

703 missing 63A

704 } 71A

not
number

not much different than above. Except it appears to be less porous. Number of slides available not adequate. Fossils in two slides examined are not abundant by any means and those present are rather small. xyl. lining in cavities same as in section immediately above. Brown mineral not present. No spherulites or unusual objects. Cavities are either filled or lined with xyls. None are partially filled.

(a glance at slide 703 would give a different impression than those (fossils) present are rather small: *Ma?* sp. very large encrusting forams & coral frags)

771-781'

705 76A
 706 86A
 707 88A
 708 92A
 709 94A

same as above. Fossils same. Cavities filled, partially filled or lined with xyls. Report states that lower part this section drilled harder and that forams were somewhat better preserved. Jaeger on forams. No brown mineral noted. No unusual objects noted.

781-790'

710 101A
 711 } 102A
 712 }
 713 104A
 714 105A
 715 107A
 716 } 108A
 717 }
 718 } 112A
 } 113A
 } 114A
 719 } 115A
 585 120A

Section same as above. Funafuti report states that it drilled harder. Thin sections show little difference in characteristics except perhaps more lichochammon toward the bottom of the section.

790-799'

720 124A

721 131A

722 133A

723 134A

724 135A

725 136A

726 { 139A
140A

I can see no appreciable difference here. xyls, cavities, fossils all about same. Lithothamnion abundant and report states it is soft and powdery. Porosity and general appearance of the section appears the same.

798-804'

727 149A

728 { 150A missing
151A

Same. Lithothamnion abundant. Forams seem to be scarce in this slide.

Continued on page 80

OTHER NOTES

Lipsman, Charles B. and Shelly, P. E.
 The Chemical Composition of Lithothamnion
 from Various Sources. Carnegie Inst. Washn.
 Publ. 340, V. 19 P 195

Table 1

1	Lithophyllum proboscideum Fosliz - Monterey, Calif	1,084*
2	Porolithon craspedium f. mayorii - Rose Atoll	1050
3	Lithophyllum kaiserii (Heydr.) Heydr - Aua Reef, Tutuila	1150
4	(same as #2)	1122
5	Goniolithon frutescens Fosliz - Nuuli Reef, Tutuila	1130
6	Amphiroa foliacea Lamx - Utelei Reef, Tutuila	1249
7	Porolithon oncodes (Heydr.) Fosliz - Fagaalu Reef, Tutuila	1225
8	Lithothamnion kaiserii (Heydr.) Heydr - Fagaalu Reef, Tutuila	1235

* Herbarium No - Univ. of Calif.

Table #3

No	CaCO ₃ %	MgCO ₃ %	Total carbonates %
1	72.	8.15	80.15
2	75.39	16.80	92.19
3	71.93	16.46	88.39
4	74.57	15.29	89.86
5	74.57	15.29	89.86
6	69.64	15.80	85.44
7	78.20	13.75	91.95
8	72.80	16.15	88.95

Lithothamnion
Table #2

	1	2	3	4	5	6	7	8
H ₂ O at 100°C	1.04	1.10	1.22	.79	.94	1.50	1.21	1.07
Loss on ignition	41.27	45.85	48.57	47.92	47.91	49.37	46.08	48.02
SiO ₂	8.38	.28	.18	.16	.22	.32	.06	.02
Fe ₂ O ₃	.64	....	....	....	....	.64	....	....
Al ₂ O ₃	.89	....	.29	....	....	....	.22	....
P ₂ O ₅	.30	.38	.38	.48	.46	.35	.25	.46
CaO	40.31	42.22	40.28	41.76	41.76	39.02	43.78	40.76
MgO	3.88	8.00	7.84	7.28	7.28	7.53	6.55	7.69
SO ₄	.97	.81	.94	.90	.91	1.08	.87	.78
Na ₂ O	2.78	2.06	2.93	1.91	1.57	x	1.42	1.10
K ₂ O	.34	.25	.49	.87	.38	x	.45	.24
Total	100.82	100.96	102.16	102.11	101.42	99.81	100.99	100.14

Clarke

Lithothamnion is a seaweed whose framework or skeleton consists of calcite; another genus, Halimeda, which is also active in making limestone, contains aragonite.

Clarke Data of Geochemistry

Amorphous CaCO₃ is more soluble than the crystalline forms. To dissolve 1 part of the former 1,600 parts of sea water are required, as compared with 8,000 parts for the xlyn. carbonate. This difference bears directly upon the theory of coral reefs. The living animal secretes amorphous carbonate, but after decomposition, a partial change to xlyn. carbonate occurs. Without this molecular rearrangement the coral would much more largely dissolve and its stability would be greatly diminished. Some resolution however occurs, especially where the waves have beaten the coral into sand, and this subject has been well studied by J. Murray and R. Irvine^①. They find that the porous corals dissolve more readily than the compact varieties.

(Clarke & Wheeler summary of analysis % MgCO₃ in inorganic matter)

Foraminifera	3.67	-	11.22	
Calcareous sponges	5.37	-	8.00	Cephalopod Argonauta
Madreporian corals	.09	-	.77	has 6.02 % MgCO ₃ and
Alcyonarians	6.03	-	15.73	Alcyonarian Heliopora
Hydroids	.22	-	1.28	is practically non-
Annelids	.00	-	9.72	magnesian.
Echinoderms	5.99	-	14.08	
Brachiopods	.49	-	8.63	
Bryozoans	.63	-	11.08	
Mollusks	.00	-	2.58	
Barnacles	.79	-	2.49	
Other crustaceans	4.84	-	15.99	

Clarke cont'd

Organisms having their CaCO_3 in the form of Aragonite were practically free from magnesia, the high proportions being found only in the calcitic shells or skeletons.

MgCO_3 tends to accumulate while the more soluble CaCO_3 is dissolved away. By leaching of carbonate deposits they become relatively enriched in magnesia, until in the extreme cases something very near the true dolomite ratio is attained. In short, a dolomite may be produced from concentration from a magnesian limestone, and either sea water or percolating waters of atmospheric origin may operate in this way.

P574-580

Coral rock, it will be remembered, consists chiefly of CaCO_3 , which in the living form is mineralogically aragonite; but in 1843, J.D. Dana,^④ in a rock from the coral island of Makatea, in the Pacific, reported MgCO_3 to the extent of 38.07%. This approached the dolomitic ratio which requires 45.7%, and the thought was at once suggested that the rock had been dolomitized by the introduction of magnesia from sea water, the latter having possibly first been concentrated by evaporation in a shallow lagoon.

Since Dana's observation was made many other investigators have recorded similar enrichments of coral reefs, and the synthetic experiments of various chemists, as cited in the preceding pages, have shown that the indicated reaction can actually take place. Klement's experiments, especially, have ^{helped to make} ~~made this~~ clear this point clear. In the coral reef of Ponta do Mangue, Brazil, J.C. Branner^⑤ reports 6.95% of MgO equivalent to 14.5% of carbonate, while the corals them-

④ Dana's Coral Island Islands. 3rd Ed. P393. (The island is called Makatea by Dana)

⑤ Bull. Mus. Comp. Zool. V44 (1906) P264

③ Edm. V42 1903
④ R. Harkness Quant. Jour. Geol. Soc. V15 (1859) P103
⑤ Quant. Jour. Geol. Soc. V61 (1905) P384 and Am. Jour. Sci. 4th series V45 (1908) P185
⑥ The Atoll of Funafuti

selves contained only 0.20 to 0.99% of MgO . In the islands of the Pacific Ocean a large number of similar cases have been observed, the analyses by E.W. Heats^⑥ reaching a maximum of 43.3% of MgCO_3 . From instances of this kind, and from the resemblance of many dolomites to reef rocks, it has been commonly inferred that dolomitization is generally, or at least often, effected in this way, lime being gradually removed and replaced by magnesia from the sea.^⑦ In other publications, Heats^⑧ has advanced additional arguments in favor of the replacement theory, and has shown that the leaching of the remains of marine organisms is not by itself adequate to account for the formation of marine dolomite. He also cites much evidence to show that the formation of dolomite takes place in shallow water.

The most striking illustration of the change from limestone to dolomite is furnished by the borings on the Atoll of Funafuti, as discussed by J.W. Judd.^⑨ The principal boring was driven to a depth of over 1,100 feet through coral and coral rock all the way, and samples of the cores were analyzed for practically every 10 feet of the distance. From the table of data presented by Judd, the following figures are selected:

MgCO ₃ in borings on Atoll of Funafuti			
Depth ft.	% MgCO ₃	Depth ft.	% MgCO ₃
4	4.23	295	3.6
13	7.62	400	3.1
15	16.4	500	2.7
20	11.99	598	1.06
26	16.0	640	26.33
55	5.85	698	40.04
110	2.11	795	38.92
159	.79	898	39.99
200	2.4	1,000	40.56
250	4.9	1,114	41.05

These figures are very remarkable. They show first, an enrichment in the $MgCO_3$ near the surface, then an irregular rising and falling in much smaller amounts, while below 700 ft. the approach to a dolomite ratio is apparent. The surface enrichment just attributed to a possible leaching out of lime salts, and the irregularities may be due in part to differences in the proportions of the various reef forming organisms. Some of these are more soluble than others, as we have already seen.

According to A.E. Finckh, the order of abundance of the organisms contributing to the Funafuti limestone is (1) Lithothamnion, (2) Halimeda, (3) Foraminifera, and (4) the corals including *Heliospongia* and other alcyonarians and the millepores. To call the Funafuti rock a coralline limestone is therefore somewhat misleading. Here at least the corals play a very subordinate part.

For the intensive study of coral reefs the analyses by Clark and Wheeler, together with those made by others, are of great significance. The limestone immediately below the zone of living forms owes a great part of its composition to all the organisms that flourished on the reef. Algae, corals, alcyonarians, Foraminifera and other forms of less importance contribute their remains to the building of the limestone, which may vary in composition as the life upon it varies. Corals may predominate in one place, algae in another. Precipitated carbonates, whether of bacterial origin or not, must also be taken into account and their quantity may be large. At first the calcitic algae, Foraminifera, alcyonarians, echinoderms and perhaps crustaceans furnish a direct supply of $MgCO_3$; but the aragonitic algae, mollusks, corals, millepores etc., by virtue of their easier alterability and consequent enrichment from sea water, may be equally significant. All classes of marine organisms contribute more or less to the formation of dolomite.

- ① The Atoll of Funafuti.
 ② A general term incl. other related algae.
 ③ *Atactites*, *Lampro*. according to L.P. Cary Proc. Nat. Sci. 1917, p. 545 alcyonarians are more important as reef builders than the stony corals.

① See E.W. Shotts Papers from the Fortugas lab. C.W. 15, 1914, p. 66 and R.L. Sherrlock, Bull. Mus. Comp. Zool. 1903, p. 349.

In this connection the report on Funafuti is remarkably suggestive. The rock throughout contained organic remains and was studied both microscopically and chemically. At a depth of 4 ft. from the surface it contained 4.23 % of $MgCO_3$ and at 15 ft. 16.4%. To this point, a concentration by leaching is strongly indicated, even if not absolutely proved; and it is probable that the relatively soluble aragonitic structures had been, in part at least, dissolved away. The fact that many sections of the core were "cavernous" in structure is evidence that solution had occurred. Furthermore, the solution must have been aided by the carbonic acid generated during the decomposition of the organic matter of the organisms, and through its agency calcite would be dissolved also.

At 26 ft. the rock contained 16 % of $MgCO_3$, but the proportion rapidly decreased, with slight variations, until at a depth of 637 feet crystals of dolomite began to appear. at 640 ft. the $MgCO_3$ suddenly rose to 26.33 %, and from that point it steadily increased until at the bottom of the boring, 1114 feet, it was 41.05 %, which is very near the figure required for pure dolomite. In short, within 3 feet the rock changed from almost nonmagnesian limestone to one that was strongly dolomitic, and in 50 feet more it became really dolomitic. This abrupt change is most easily explained upon the hypothesis that the dolomite at the bottom of the Funafuti boring represents an old reef which was submerged by one of those fluctuations in the level of the ocean which are known to occur elsewhere. After a long rest it was again elevated to the surface, and then a new period of reef building began. The new reef is superimposed upon the old one. The assumption as to changes of level here is supported by the fact that on other islands in the South Pacific dolomitized reefs are found at hundreds of feet above sea level. ①

Although the chemical composition of the Funafuti limestone

has been more thoroughly studied than that of the limestone at any other locality, the general process is not necessarily the same elsewhere. Its details may be duplicated, but their order is often different. Something of this sort is shown by the following analyses by George Steiger² of borings from an artesian well at Key West, Florida.

Lime and Magnesia in borings at Key West

Depth Ft.	CaO%	MgO%	Depth Ft.	CaO%	MgO%
25	54.03	0.29	1325	54.49	0.62
100	54.01	.77	1400	55.12	.30
150	54.38	.86	1475	54.48	.73
350	51.46	1.67	1625	53.90	1.14
600	48.87	2.50	1850	54.28	1.12
775	46.53	6.70	2000	54.02	1.06
1125	53.84	.86			

Here there is a progressive magnesian enrichment down to 775 ft., and then a falling off, but no such thorough alteration appears as at Funafuti. What different conditions may have existed to account for these differences of composition is not known.

It is of course evident that dolomitization by replacement need not be limited to the action of sea water upon coral reefs. Magnesian spring waters may be equally effective, and are so locally, as observed by J. C. Spurr³ in the rocks about Aspen, Colorado.....

From what has been said already, the chief chemical processes involved in the formation of marine dolomite may be summarized as follows: First, the mixed carbonates may be directly precipitated in shallow waters, either by changes of temperature and concentration of atmospheric CO_2 , or by ammonium carbonate produced during the decomposition of the remains of

marine organisms. In the latter process, however, CO_2 is also formed, which tends, more or less, to retain the carbonates in solution. Here, then, are two opposing processes, and the extent of precipitation is therefore variably limited. Second, the carbonates contained in the shells or skeletons of marine invertebrates are decomposed. Third, MgCO_3 is concentrated by the leaching away of the more easily dissolved calcium salt. Fourth, the so-called coralline rock is enriched at the expense of the magnesium salts contained in sea-water. All four processes may be in operation simultaneously, one or another predominating according to conditions which are not likely to be quite the same at any two localities. The fourth process, however, is generally the most important, and it precedes the union of the carbonates into true dolomite.

The leaching process, which commonly follows the line that has already been emphasized, may, however, sometimes be reversed. The comparatively soluble trihydrate of $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$, which is represented in nature by the rare mineral nesquehonite, is known to occur in the form of stalactites in certain coal mines, where it was probably produced by the percolation of groundwaters rich in magnesia and in CO_2 . This reaction may account for the fact that in many localities fossiliferous beds overlie beds of limestone which are richer in MgCO_3 , an enrichment having taken place analogous to that which is so fully recognized in modern studies of ore deposits.

This process has been given emphasis by General E. Gourdy⁴, who regards it as an important step in the development of dolomite.

The magnesium carbonate thus transferred from the upper to the lower strata he believes is derived from the remains of marine algae and other organisms. Whether complete dolomitization can be effected in this manner, is however, doubtful.....

Van Dijk's memoir is an excellent critical summary of all the different views as to the origin of dolomite and is rich in references to literature.

Under ordinary ^{atmospheric} conditions and aqueous conditions dolomite alters like limestone, but less readily.

Lill

Sand drilled into at Bikini is not amorphous but fine, x-lup organic sand probably mostly CaCO_3 . It is not therefore easily ~~altered~~ dissolved nor altered to dolomite. It is all tied up in the proximity of ions to one another. In a solid x-lup rock it is easier for ion and atom exchange to take place because of the delay due to lack of porosity which increases the time of contact of the ions and because of the proximity of the ions in a dense rock once it becomes saturated with sea water. The abundance of ions present in a dense rock as compared with unconsolidated material which is mostly porous spaces should also be a factor. This may have some bearing on why dolomitic ls. is found under Funafuti and not under Bikini. Why we ~~have~~ have sand under Bikini I do not know as yet. (8-9-49)

Handbook on the Trust Territory of the Pacific Islands. Navy Dept. (1948) Washington (25) D.C.

Geology

The Comparative Localities of Bikini and Funafuti atolls

Bikini Atoll

Bikini Atoll is located between $165-166^\circ \text{E}$ and $11-12^\circ \text{N}$ in the Northern Marshall Islands. It is within the trade wind belt and just beyond the typhoon area of the Pacific. The climate is mild ^{outside} with an average annual temperature of 81 degrees with a maximum of 89 and a minimum of 77. The atoll is made up of 36 islands which enclose a lagoon that is 229.40 square statute miles in area, but which themselves comprise a total land area of only 2.32 square statute miles. The annual precipitation for the area is about 158.6 inches. The atoll is in the area affected by the North equatorial current and lies just north of the region coming under the influence of the counter equatorial current. Currents are in general quite variable and are affected both by the wind and current systems of the Pacific and by obstructing islands, sea mounts and tides.

The Marshall Islands lie in two great ^{roughly parallel} arcs, which trend about $N 35^\circ W$ for a distance of approx. 700+ miles. At the northwestern end of these two arcs we can imagine a line a joining of their longitudinal axes and it is at this juncture that we find Bikini Atoll. The Atoll is located at the SW end of a large sea-mount which trends due NW-SE and the summit of which lies at a depth of 1000 fathoms ~~beneath it~~ below sea-

sea-level. Measured across the 2000 fathom contour from SE to NW the sea mount is 80 miles long and from SW to NE 20 miles wide. (See fig. -) while Bikini atoll itself is about 20 miles long by 13 miles wide.

Structure

The atoll is composed of ~~an~~ structurally of a framework of coral and lithothamnion algae the latter supplementing the former with some aid from encrusting corals and foraminifera. This structure is strong but is cavernous. The interstices are filled with calcic organic debris from corals, mollusks, halimeda, foraminifera and ~~a~~ minor forms of animal invertebrates. The debris filling may or may not add to the strength of the atoll, ~~but~~ depending upon the degree of cementation but in any case it adds to the mass and volume. In the case of Bikini the debris ~~now~~ composes approximately 95% of the entire structure.

Terrace

That part of the atoll extending down to a depth of about 60-75 fms is evidently constructed on an old platform that was once above sea level itself. This is evidenced by a subsurface terrace at that level which is found ~~both~~ ^{east, north and northwest sides of} on the seaward and lagoon sides of the reef and islands.

Surge Channels

On the landward side of the atoll, the reef is characterized by many re-entrants and submarine ~~tidal~~ ^{or surge channels} and grooves, which have ~~been~~ ^{act} as an effective buffer against the

onslaught of the sea. It is difficult to determine whether these grooves have resulted in growth of the coral and algae as a protection for the atoll structure, or whether they have been actually cut by wave and tidal action. It is believed however that the two have proceeded hand in hand and because of this there is no discernable difference between these two possible origins of the grooves. The relationship of these surge channels and re-entrants to the wind direction has been shown by Emery-Tracy and Ladd (1949) which indicates that they are only formed as a combination of wind driven wave action and reef growth.

The lagoon bottom of the atoll is far from smooth, as has been propounded by ^{some} students of atolls in the past, but is covered by hundreds of coral knolls which have grown upwards from a max. depth of 30 fathoms to within 10 or 12 fathoms of the surface (Emery 1948). The lagoon bottom itself ^{around the base of the knolls} is literally covered with halimeda and foraminiferal debris.

Beach Rock

Beach rock, or beach sandstone is a common feature on the seaward side of most islands of the atoll. In some cases it is featured on the lagoon side as well but generally it is not developed to such a marked extent. The lagoon beach rock is ^{often less well} ~~often less well~~ cemented and generally is not so thick as that toward the sea.

often as
time to
time would
M.P.
Not space
as you intend

In practically all cases, either seaward or

lagoon, the beach rock dips toward the water with a dip of about 10 degrees. This dip is dictated by the angle of repose of the beach sands. ~~in the same manner, the~~ Likewise, the strike is determined by the strike of the beach prior to lithification. Nowhere is there any surface evidence that the beach rock has been distorted or changed from its original since diagenesis first set in.

There is probably little doubt as to the causes of cementation of beach rock although much has been written on the subject. It has been attributed to the leaching and redeposition of CaCO_3 by rainwater and by sea water both of which probably play important roles. I believe however that the pH change of ocean spray changes is adequate to cause considerable leaching of CaCO_3 and its redeposition at a lower level in the sand. Rainwater on the other hand is not likely to play so large a part because of its infrequency and different pH. Another, and very obvious, reason for the seawater to for stating that seawater is the prime factor here is the fact that the beach rock is confined to the periphery of the islands at the boundary of sea and land. Witness the fact that it is formed inland at a depth of approx. 4 ft. only to a very slight extent. The beds observed in a trench on Bikini were very poorly developed, i.e. only a few

look up
Ph. of
seawater
etc.

inches thick and loosely cemented. Beach rock is then a phenomena of the boundary between land and sea and must be attributed to the constant interaction between these two agencies.

Incidental
note to be
looked into

Trinde (Funafuti report P. 188) says no trueoolitic material was found neither in the loose or solid material. (See slides 503 and 628)
Lobophyllum spiculus

Problems of Comparing Bikini and Funafuti

1. Why is Funafuti apparently consolidated and well cemented and also bleached while Bikini is more solid, unconsolidated, low CaCO_3 sand grain? Below is the answer:
2. Why is Funafuti all recent down to 100 ft. while Bikini is older?
3. Look for evidence of zones that might correspond to Pleistocene developing at Bikini and Funafuti.

Funafuti Report: "From Burghaus's 'Phykalischer Atlas' (II Abt., I Hydrographie, Taf. VI) Funafuti appears situated just on the inside of a circular current which sweeps in a northwesterly direction, skirting the NE side of the Ellice group, thence trending westerly between the Ellice and Marshall Islands, thence in part turning south towards the Santa Cruz Islands, and finally recurring toward the southern end of the Ellice group. The direction in which pumice has been found to drift across the Pacific to the Ellice group is also in favor of an easterly current. On the whole, therefore, it appears that whereas a WNW current usually prevails at Funafuti during the trade wind season, an easterly current may prevail at other seasons of the year.

1. Get more complete x-ray work done on Funafuti. 7 Analyses already made.
2. See about Paleo-T measurements that Epstein is supposed to be doing on the Bikini material at the Institute for Nuclear Studies, Univ. of Chicago.
3. Pick Funafuti cores for further x-ray and/or spectro-analysis from critical ~~analysis~~ areas. Run through the core first in comparison with Bikini

Dredged volcanics () from 10,608 ft. on sea floor at Funafuti. (Funafuti report chart).

BIKINI - FUNAFUTI CHECK OFF LIST

- (A) General appearance of section:
 - (I) Color - brown, white, dark, mottled
 - (II) Type - fragmented, mostly fossils, mud, etc.
- (B) Fossils
 - (I) Generic types, if known
 - (II) Original shell, cast, mold, recrystallized
 - (III) Altered, broken, disintegrated
 - (IV) Color, brown, white etc
 - (V) Fossil cavities - empty, mud, detritus, crystals, solid calcite etc
 - (VI) Orientation - if significant
- (C) Calcite or Aragonite
 - (I) Crystals - acicular, stubby, encrustations, minor or heavy cement.
 - (II) As cement - well cemented, poorly cemented, porous, etc.
- (D) Cavities (Interspaces)
 - (I) Filling - type of calcite or aragonite, mud, extent
 - (II) Filling - calcite, aragonite, mud, detritus, extent
 - (III) Abundance
 - (IV) Alteration around cavity walls
- (E) Grains
 - (I) Detritus, spherulites, CaCO_3 sand, fossil fragments
 - (II) Angular, subangular, rounded
 - (III) Approx. size
 - (IV) Coating on grains - oxides, calcite x-lvs, etc

(over)

(F) UNUSUAL OR UNIDENTIFIED OBJECTS

(I) Description

(II) Sketch

Thin sections from Funafuti picked for Pita Pita examination

Sl. No.	Depth	Core	Remarks
✓502	0-10	1	encrusting forams
✓627	20-30	32	encrusting forams
✓617	30-40	42	encrusting forams
✓628	50-60	62	encrusting forams
✓512	60-67	60	forams - check for rotalia and few others
✓634	70-80	84	
✓517	100-105	110	forams of varying sorts plentiful
✓516	100-105	110	" " " " "
✓632	120-130	123	" " " " "
✓520	150-160	141	
✓522	160	141	
640	170-180	145	
642	180-190	151	
643	180-190	158	
645	200-210	178	
646	210-220	180	
648	210-220	183	
649	220-230	186	
650	280	198	
651	373-378	204	Rotalia calcar
652	373-378	205	Rotalia calcar
653	415-417	207	
654	415-417	212	
655	430-432	215	

Slide 512 is
50'-60'-NOT 60-67
M.P. - See last

535	517-526	247
537	528-578	304
544	637-643	318
654	449-452	226
661	497-503	243
663	506-517	255
664	525	263
665	526	269
666	526-546	274
667	526-546	284
668	547-555	294
669	547-555	296
670	567-578	296a
671	567-578	296b
672	603-612	305
675	624	307
676	637-643	314
677	637-643	314
678	643-652	328
679	643-652	328

Cyclodypena

Funafuti
Cores chosen for Chemical Analysis

N ^o	Ft.	N ^o	Ft.
34 ✓	0	314 ✓	638
15 ✓	15	316 ✓	640
60 ✓	50	163A ✓	810
110 ✓	100	202A ✓	824 ea
144 ✓	170	203A ✓	826
150 ✓	180	254A ✓	855
159 ✓	190	267A ✓	866
176 ✓	200-210	320A ✓	881
180 ✓	210-220	486A ✓	980
186 ✓	220-230	491A ✓	983
200 ✓	375	504A ✓	991
205 ✓	378	603A ✓	1059
213 ✓	417	618A ✓	1061
214 ✓	430	634A ✓	1070
223 ✓	449	709A ✓	1114
296 ✓	555	11A ✓	720
307-308-309 ✓	576-578	398A ✓	935
313 ✓	624-637	320 ✓	646
	637		

Add To core for chem.
analysis.
320
202A

GORDON! You may
have intended 320 but
you got 320A = 881

804'-810'

729 161A
 729A 163A
 730 165A
 731 174A

Hard section again. Xyls in cavities are somewhat better developed than preceding. Cementation probably better. Forams seem to be normal abundance again.

810'-815'

Photo
 732 } 183A
 733 }
 734 184A
 735 185A

Distinct layering of secondary xylem material noted in cavity lining for first time. Funafuti report states that corals are definitely replaced and infilled with consolidated mud. This section shows nicely many partially filled cavities filling covered over with layers of xylem material.

Maybe some change here

get photo here #732

xyls layering

815-822'

736 187A

737 197A

Still hard dolomite. Report states whitish portions are soft and brown portions hard. Layering in xylem layers still present. Brown mineral is present in some cavity fillings it is on the inside of the xylem layers. Forams are present but not abundant in any form.

Cavity lining
layering

822'-833'

586

203A
204A

738

205A

739

208A

740

213A

Layering in dolomite cavity linings somewhat more pronounced. Forams scarce with exception of *Carpenteria*. Cavities maybe either completely filled or lined. Partial filling not noticeably present.
Read section 710 for photo of layering.

Cavity lining
layering

833'-844'

741 217A
742 222A
743 224A
587 225A
744 226A
745 229A
746 230A

Banding still pronounced in upper portion of this section. Marginopora appear in abundance along with other forams. % Calcite higher at 838 feet, and banding of xyl cavity filling layers disappears. Single layer xyl incrustations only are present. Cavities partially or completely filled. Some non xyl. mud noted. Section still listed as hard drilling by Funafuti report.

Cavity lining layering
upper portion

Disappears lower part

844'-853'

747 235A
748 237A
749 246A

Banding not present in cavity fillings in upper portion this section but reappears again in the lower part. Upper portion cavities also show non-xyl mud filling in cavities some of which are only partially filled. No mud filling noted when banding reappeared. Forams are abundant in upper portion this section and practically disappear in lower part.

Cavity lining appears
lower part

853'-866'

750	250A
751	258A
588	267A
752	268A
753	269A 270A
754	271A

Agate like banding of cavity infillings is unmarkable in this section. Crabs completely replaced by this banded structure in slide #754. Forams present but not too abundant. Coral seems to be abundant in this section and some lithothamnion.

Rock generally hard according to Funafuti Report.

Cavity lining layering

866'-874'

755	281A
756	282A 283A
757 mining	287A
758	288A
759	289A 291A

Spicules very abundant in lower section of hole. banding not evident in slide 755 but is very marked in cavity linings of other slides. Forams present but not abundant. Coral prevalent. Brown mineral present on inside of cavities.

Hard rock according to report.

Cavity lining layering

most
mining
282

874' - 881'

760 ^{missing}	306A
761	307A
762 ^{missing}	309A
763	

w.

Agate type banding not present in slides examined here. Single layer xylm. infilling only noted in cavities. Slides 760 and 762 missing however. Forams are numerous. Brown mineral present. Hard rock.

881' - 890'

764	311A
765-768	312A
769	314A
770	315A
590	319A
591	321A
592	321A
771	321A
(589 P) MP	(3190) MP

Agate type banding not present in 764 but shows up well in rest of slides. Marginopora abundant again. What was thought to be mud filling in last 10 or so feet is corbairundum grinding compound. Slides were poorly washed after grinding. Coral abundant this section as shown by large slides 590-592. Cavities show partial filling in places.

Cavity lining layering

890'-899'

773

772

329A

336A

774

337A

agate type banding not seen in this section. *Margosphaera* present but not abundant. Porous spaces are numerous but small. single layer xyl. lining in cavities. *Funa-*
futi report states "the banded xyl. dolomite lines some of the cavities." I did not observe banding only xyl. single layered encrustations. Report states hard rock

899'-910'

775

342A -

344A

776

345A

777

352A

Hard dolomitic limestone (Report). Some agate banding present but not pronounced. Corals present partly filled or casts some empty. Forams and algae present but not abundant. Dolomite present is still granular appearance. No brown mineral. No oddities.

Cavity lining layering

910'-922'

778 360A
 779 361A
 780 363A
 781 364A
 782 371A
 372A
 374A
 376A

(593, 594) (373A, 374A)
 2nd

Hard dolomitic limestone according to report. Report states also cemented by xylm. Dolomite. Marginopora, amphistegina, rotalia? and carpenteria all present. Coral present. Cavities lined for most part with 1 layer xylm or xylm material in some cases two layers. Some cavities filled or partially filled with what was once mud now xylm dolomite? Small amount brown material noted.

MUD922'-936'

783 377A
 784 379A
 388A
 389A
 398A
 399A
 785 400A
 401A

Hard dolomitic limestone according to report. Agate like banding present throughout. Dolomite still in xylm mosaic pattern. Cavities almost all filled. Some are only lined with xylm dolomite layer. Marginopora, amphistegina and other forams present but not numerous. Rotalia not noted. Coral present.

Cavity lining layering

936' - 945'

786 405A
406A
787 413A
414A
788 417

Hard, dolomitic limestone. More coral present than in preceding section. Cavities, xylm. material etc. exactly like preceding section

Cavity lining layering

945' - 957'

789 424A
790 425A
791 427A

Same as above except agate banding not present. Only single xyl layer on inside cavities. xyls. are mosaic pattern in cases where cavities are filled. Coral structure preserved by dirty thin line which outlines structure. Line always appears on backside of xyl layer.

957' - 963'

792 443A
 596 445A
 597 446A
 793 448A

Hard, dolomitic limestone. agate banding not present in cavity linings. Single layer xyl. dolomite only. Cavities either filled, empty, or lined with xyl. dolomite mosaic. *Marginospora* abundant. *Amphistegia* and other forams present plus corals etc. essentially same as section above.

963' - 973'

794 456A
 457A
 598 470A

Same as above. No agate banding

973'-983'

795 476A
477A
796 481A
484A
797 487A
488A

Same as above. Coral interspaces filled forming casts. This more noticeable here than in last several sections. Forams about the same. agate banding not present. Section appears to be more porous than preceding sections.

983'-991'

798 491A
494A
799 502A
504A

Forams markedly more abundant. Partial cavity filling quite noticeable. Report states hard dolomitic limestone here. Agate layering appears again in lower part of section #799.

Brown color begins to appear in the dolomite.

Get sections here and sample cores for testing.

MUD

991' - 1006'800
801 518A

802 515A

599 519A
803 520Aagate banding present. Crals as casts. Forams present
but not abundant. Cavities filled or empty.

Grayish brown

Cavity lining layering1006' - 1015'

804 534A

805 537A
538AGrayish brown hard xgh. dolomite. Agate banding present but
not too noticeably. Forams present but not abundant.
Section appears less porous.

1015'-1025'

806	551 A
	553 A
807	562 A
	564 A

agate banding not present. single layer xyls. only.
 Forams scarce.
 full brown color according to report.

1025'-1034'

808	573 A
	575 A
809	576 A
	577 A
810	578 A
	579 A
600	582 A

Same as above.

1034'-1044 1/2'

811 584A

812 590A

813 593A
594A

Cyclolypus appears again. Forams abundant.
Agate banding absent.
Grayish brown hard dolomitic limestone.

Cavity lining layering1044 1/2'-1053'

814 603A

815 606A

Same as above. Forams not so abundant in fact
scarce.

1053-1066'

601 618A

816 620A

817 621A

818 623A

819

Same as above. Agate banding appears lower part of section in minor way. Forams plentiful.

Cavity lining layering

1066-1075'

820 629A

821 639A
640A

Same as above. Agate banding present. Forams plentiful. Fumafuti report states section is poor in corals.

Cavity lining layering

1075' - 1087'

822

644A

Same as above.

823

646A

1087' - 1100'

824

665A

Partial $\odot$ cavity fillings noticeable in lower
part together with near obliteration of forams.
Agate banding still present.

825

675A

826

677A

827

680A
681A

828

682A

MUD

(602?)

1100' - 1114 1/2'

829	693A
	694A
830	699A
	700A
831	701A
832	703A
833	705A
	706A
834	707A
603	709A

Same as above. Agate banding absent. *Marginozoua*
exceptionally abundant.

Funafuti
ReportTHE MINERALOGICAL CHANGES OBSERVED IN THE CORES OF THE
FUNAFUTI BORINGS - C. Gilbert Cullis

Calcite - aragonite - dolomite determinations made by
micro-chemical means.

PP392-393

1. Meigen test - aragonite stains, calcite & dolomite unstained
2. Lemberg test - calcite & aragonite stain, dolomite unstained.

Aragonite

Halimeda

P393

Madreporarian corals

Heliopora

most mollusca

tunicate spicules

Calcite

Lithothamnium

Lithophyllum

Foraminifera

Alcyonarian spicules

polyzoa

Echinodermata

States that dolomite is always of secondary origin. (?)

P393

Aragonite - upper cores

↑ Calcite - upper & lower cores

↓ dolomite - lower cores

Aragonite has not been found in association with dolomite

394-395

Secondary calcite may form upon either a calcite or aragonite organism. Secondary aragonite forms only upon aragonite organisms and then only if clean. A thin film of dirt seems to preclude this formation, and calcite forms. Secondary aragonite practically confined to cavities within the organisms because of these factors.

A COMPARISON OF
FUNAFUTI AND BIKINI ATOLLS

PART-I. THE GENERAL BACKGROUND

(I) INTRODUCTION:

(A) COMPARATIVE LOCATIONS.

- (1) Geographically. (chart showing Marshall & Ellice Is.)
- (2) Oceanographically.
- (3) Climatically.

(B) COMPARATIVE SIZES.

- (1) charts to scale Bikini & Funafuti Atolls and Bikini & Funafuti Islands.
- (2) Number of Islands.
- (3) Area.
- (4) Depth of Lagoon.
- (5) Number of sea-mounts
- (6) Comparative shape.

(C) ACKNOWLEDGEMENTS

- (1) Harry Ladd
- (2) J. I. Tracey
- (3) etc.

(II) GEOPHYSICS:

(A) GEOMAGNETICS:

- (1) Comparative magnetic charts.
- (2) Interpretation Magnetic charts.

(B) OCEANOGRAPHY (COMPARATIVE)

- (1) Chemical
- (2) Physical

(C) METEOROLOGY (COMPARATIVE)

- (1) Temperature.
- (2) Rainfall.
- (3) Frontal Belts
- (4) etc.

(D) TECTONOPHYSICS AND SEISMOLOGY

- (1)
- (2)
- (3)
- (4)

(III) MARINE AND TERRESTRIAL LIFE:

(A) MARINE LIFE:

- (1) Lagoon.
- (2) Reef.
- (3) Ocean.

(B) TERRESTRIAL LIFE:

- (1) Flora.
- (2) Fauna.

PART-II. THE GEOLOGY

(I) INTRODUCTION:

(A) GENERAL COMPARATIVE GEOLOGY

- (1) SURFACE GEOLOGY.
- (2) SUBMARINE GEOLOGY.

(II) SUBSURFACE GEOLOGY

(A) THE DRILLING:

- (1) Method.
- (2) Rig.
- (3) Location of holes (chart).

(B) COMPARISON OF CORE MATERIAL.

- (1) General Discussion - Depth, % age cored, etc.
- (2) FOSSIL COMPARISON
- (3) MINERALOGICAL COMPARISON.
- (4) SEDIMENTARY COMPARISON.
- (5) CHEMICAL COMPARISON.

116

117

	Core Number	Depth	Remarks
1	2-1-1	14 Ft.	Described by JIT. Beach Sandstone. Picture and x-sect. made.
2	2-6-1	95 ±	Des. by JIT. Recent-Plio-Pleistocene break? 105'
3	2-7-1 2-8-7	116 150 ±	Des. by JIT. Above possible break at 185' } casts at 190'
4	2A-13-3	210 ±	Des. by JIT. Below possible break at 185' }
5	2A-21-2	290 ±	Des. by JIT. Partly reworked chalky Ls. } Break at 293' (?)
6	2A-26-3	330 ±	Des. by JIT.
7	2A-28-6	447 ±	Des. by JIT.
8	2A-30-2	520 ±	Des. by JIT.
9	2A-31-1	570 ±	No Core No. Des. Tan color begins.
10	2A-32-1	640 ±	No Core No. Des.
11	2A-33-	700 ±	33-1 Des. by JIT. Look for large piece. } Break at 726' (?)
12	2A-35-	870 ±	No core Des. No return between 700-870' }
13	2A-37-15	940 ±	Des. by JIT. Unaltered shallow water corals.
14	Rock Bit	1127-1151'	Hard brown Ls. Cuttings should be good Des. by JIT
15	Rock Bit	1230 ?	Sample should be chosen Carefully in this area.
16	Rock Bit	1750 ±	Sand
17	Rock Bit	1900 ±	Sand
18	Rock Bit	2000 ±	Sand Break } 2070 (?)
19	Rock Bit	2100 ±	Sand, Break }
20	Rock Bit	2200 ±	Sand
21	Rock Bit	2300 ±	} 90% Lithothamnion sand
22	Rock Bit	2350 ±	
23	Rock Bit	2400	
24	Rock Bit	2500	
25	Rock Bit	2556	Bottom

120
slide
Number

Funafuti Slides For Photographing

TO SHOW

- 635 ✓ Upper left hand corner of slide to show xyle filling in cavity Notes P12
849 ✓ Show loss of fresh appearance of organisms. Notes P14
641 ✓ Loss of fresh appearance and heavy recrystallization. Notes P16
see also Martins comments on slides 523-524
642 ✓ Appearance of white powdery material in interstices for first time ^{P16}
~~643~~
651-652-524 ✓ Appearance in section of *Rotalia calcar* first time (P26 notes)
662-663 ✓ Unusual altered condition of the forams. (P34 notes)
671 ✓ Show *Cyclodypena* for first time (P40 notes)
565 ✓ Show alignment of forams. (P46 notes)

Partial Mud Fillings

634-635 ✓

523-524 ✓

531-655 ✓

656-533 ✓

657-658 ✓

665-666-667 ✓

536-668-669 ✓

671-545 ✓

689-690-694 ✓

732-733-734-735 ✓

747-590-592 (592 coral in upright position of growth)

778-779-827 (827 coral in upright position of growth)

798-799-828 ✓

Cavity lining layering

732-736 ✓

738-741 ✓

749-754 ✓

756-765 ✓

775-783 ✓

786-800-801 ✓

804-818-819 ✓

821 ✓

Gordon G. Lill

Funafuti (8°26'36" S; 178°55'22" E)

Surface Chlorine/litre = 19.60

One fathom " = 19.24

30 fathoms " = 19.66

Surface (CO₂/litre) 0.132

One fathom 0.132

30 fathoms 0.132

63 slides

Emery, K. D.

Marine Solution Basins, *Journal of Geology*. Vol. LIV, No. 4 July 1946

Ratios of Calcite and Dolomite in the Carbonate Fraction

TYPE	% CALCITE	% DOLOMITE	APPROX. MgO EQUIV.
Limestones	>95	<5	0 to 1.1
Magnesian Limestone	>90 <95	>5 <10	1.1 to 2.1
Dolomitic Limestone	>50 <90	<50 >10	2.1 to 10.8
Calcitic Dolomite	<50 >10	>50 <90	10.8 to 19.5
Dolomite	<10	>90	19.5 to 21.6