final step is more convenient for counting the beta-activity of Np^{239}.

TABLE II
Co-precipitation of Np^{239} with Zr-mandelate

No.	c.p.m. of Np^{239} added	c.p.m. of Np^{239} carried with Zr-mandelate
1	925	915
2	1063	1060
3	808	810
4	1320	1305

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X-RAY PATTERNS OF MOLLUSC SHELLS FROM INDIAN WATERS

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1. MATERIALS

It is well known that the shells of molluscs consist of layers of calcium carbonate interspersed with protein layers and that the calcium carbonate occurs mostly as calcite or aragonite, and more rarely as vaterite.[1] Some studies have been made on this subject and are summarised by Jean Bouillon.[2] These, however, appear to have been made on specimens obtained from the temperate latitudes. The author is not aware of any reports of X-ray studies of the nature of the inorganic component in mollusc shells occurring in Indian waters. A study was therefore made of the X-ray diffraction patterns of a number of typical specimens obtained from the beaches of Madras State. The specimens studied are listed serially in Table I giving their class, sub-class (if any), order, family and genus. A fair number of specimens contained in this list have also been studied by Jean Bouillon.[2] These are indicated by a mark (√) in Table I.

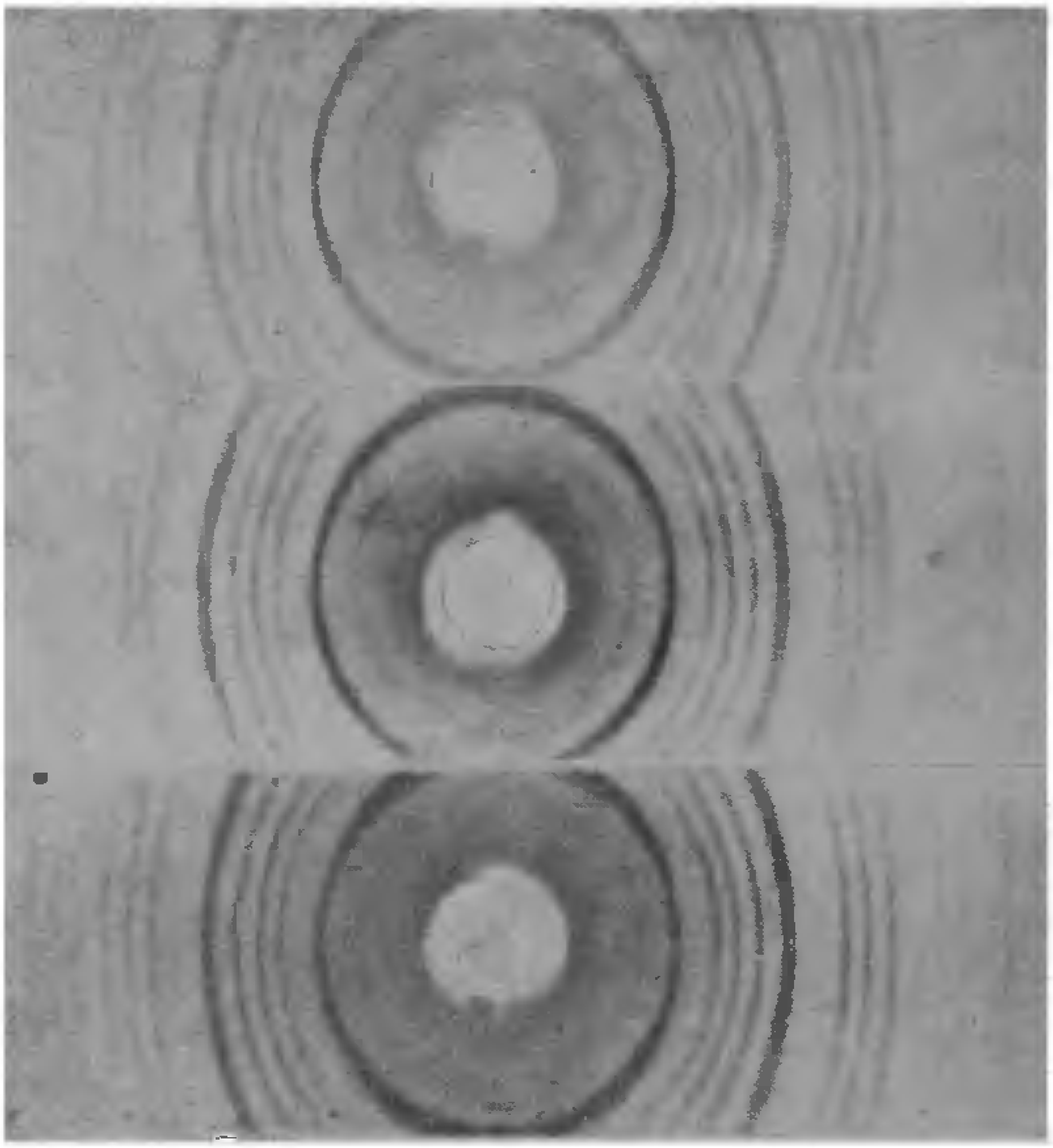
TABLE I
List of the shells studied with their identifications

Class—Gastropoda
Sub-class—Prosobranchia
(A) Order—Megagastropoda
  (*a*) Series—Strombacea
    Specimens 1 and 2 Strombidae, *Strombus* (A) (Two different species)
  (*b*) Series Cypraeacea
    Specimens 3 and 4 Cypraeidae, *Cyprea* (A) √ (Two different species)
  (*c*) Series—Cerithiacea
    Specimen 5—Turritellidae, *Turritella* (A) √

TABLE I—*Contd.*

(B) Order—Stenoglossa
  (*a*) Series—Buccinacea
    Specimen 6—Volemidae. *Hemifuscus* (A)
    Specimen 7—Fasciolariidae, *Fasciolaria* (A)
(C) Order—Archaeogastropoda
  (*a*) Series—Zeugobranchia
    Specimen 8—Haliotidae, *Haliotis* (A)
  (*b*) Series—Trochacea
    Specimen 9—Trochidae, *Trochus* (A)
  (*c*) Series—Patellacea
    Specimen 10—Patellidae, *Patella* (C) √
Class—Lamellibranchiata
(A) Order—Eulamellibranchiata
  Sub-Order—Heterodonta
    (*a*) Series—Veneracea
      Specimen 11—Veneridae, *Meretrix* (A)
  Sub-Order—Schizodonta
    (*a*) Series—Unionacea
      Specimen 12—Unionidae, Unioninae. *Lamellidens* (A)
(B) Order—Anisomyaria
  (*a*) Series—Pectinacea
    Specimen 13—Pectinidae, Spondilinae, *Spondylus* (C) √
Class—Cephalopoda
Sub-Class—Tetrabranchiata
Order—Nautiloidea
Specimen 14—Nautilidae, *Nautilus* (A) √

(C) = Calcite; (A) = Aragonite; √ = Also listed in Ref. 2.

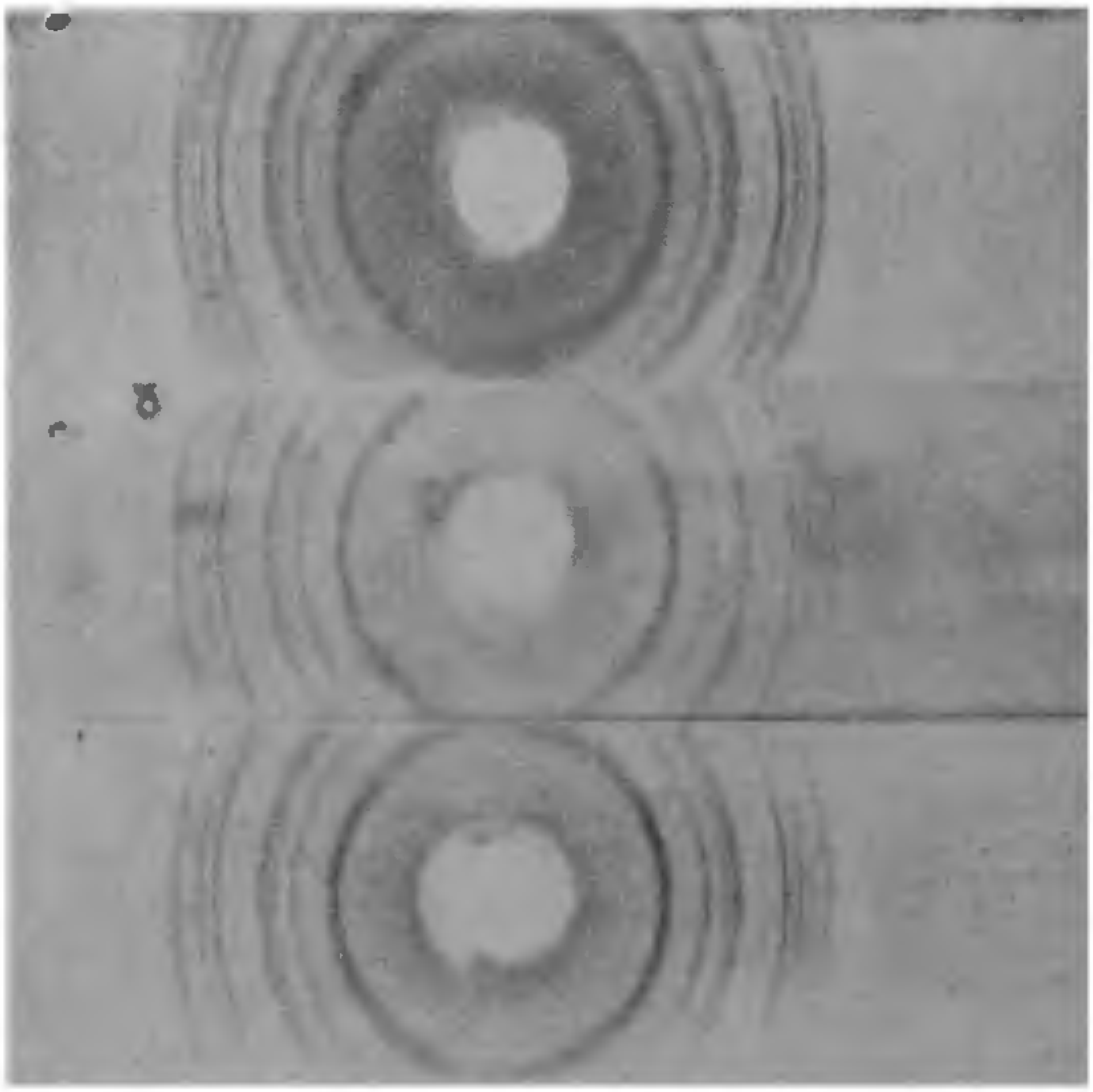


(*a*)

(*b*)

(*c*)

FIG. 1. X-ray diffraction patterns of specimens showing a typical calcite pattern. (*a*) Mineral specimen. (*b*) Shell No 13. (*c*) Hen egg shell.



(*a*)

(*b*)

(*c*)

FIG. 2. X-ray diffraction patterns of specimens showing a typical aragonite pattern: (*a*) Mineral specimen. (*b*) Shell No. 1. (*c*) Coral specimen.

However, it is not known whether the actual species under the particular genus which has been studied are the same in both studies (Bouillon also has not listed the name of the species). All the specimens belong to the phylum Mollusca. The results of the studies are reported below. As a part of the study two non-mollusc specimens, namely, a coral (phylum-Coelenterata) and a hen egg-shell were also studied.

2. Method and Results

The X-ray patterns were taken with a Philips 57·3 mm. powder camera using copper Kα radiation. Figures 1 and 2 give typical examples of the patterns recorded. The spacings of the lines observed in the powder patterns of all the mollusc specimens along with the visually estimated relative intensities are shown is Tables II A and II B. The measured data of the first few lines down to a spacing of about 1·9 Å are listed. The first two columns in each table contain the standard spacings and intensities, as reported in the A.S.T.M. Index for calcite and aragonite respectively. The measurements reported in Columns 3 and 4 on a standard mineral specimen show the accuracy that may be expected from the experiments. It will be seen that the specimens in each group contain almost exclusively one inorganic compound, namely, either calcite or aragonite. From the fact that no powder lines other than those of the identified components are recorded in the patterns, the author estimates that, if at all the other polymorphs of calcium carbonate exist in the shells studied, they form less than 50% of the prominent material of the shell. Only in the case of specimen 9 is a faint trace of the strongest line of calcite ($d = 3 \cdot 04$ Å) found among the powder lines of aragonite (*see* Table II B).

Table II

Measured data on the X-ray diffraction patterns

A. Calcite patterns

Ring number	A.S.T.M. Index		Calcite mineral		Specimen 10		Specimen 13	
	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.
1	3·86	12	3·86	w	4·04	w	3·86	w
2	3·[illegible]4	100	3·03	vs	3·15	vs	3·05	vs
3	2·85	3	2·82	vw	..	..	..	..
4	2·50	14	2·49	s	2·60	m	2·49	m
5	2·29	18	2·28	s	2·37	m	2·30	m
6	2·10	18	2·09	s	2·16	m	2·10	m
7	1·93	5	..	..	..	..	..	..
8	1·91	17	1·91	s	1·97	m	1·9[illegible]	m
9	1·88	17	1·84	s	1·93	m	1·8[illegible]	m

B. Aragonite patterns

Ring number	A.S.T.M. Index		Aragonite mineral		Specimen 1		Specimen 2	
	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.
1	4·21	2	..	..	..	..	..	..
2	3·40	100 }	3·44	vs	3·43	vs	3·43	vs
3	3·27	52 }			3·28	s	3·24	m
4	2·87	4	..	..	..	..	..	..
5	2·73	9	..	..	..	..	..	..
6	2·70	46	2·77	s	2·73	s	2·74	s
7	2·48	33	2·54	m	2·51	m	2·50	m
8	2·41	14	..	..	..	..	..	..
9	2·37	38 }	2·42	s	2·[illegible]9	m }	2·38	s
10	2·34	31 }			2·35	m }		
11	2·33	6	..	..	..	..	..	..
12	2·[illegible]9	11	2·24	w	2·21	vw	2·[illegible]0	vw
13	2·11	23	2·16	w	2·13	w	2·13	w
14	1·98	65	2·03	s	2·00	s	1·9[illegible]	s
15	1·89	32	1·98	m	1·[illegible]0	m	1·90	m

TABLE II—*contd.*

B. Aragonite Patterns (*Contd.*)

Ring number	Specimen 3		Specimen 4		Specimen 5		Specimen 6		Specimen 7	
	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.
1	..	..	..	..	..	..	..	..	..	..
2	3·37	vs	3·33	vs	3·45	vs	3·43	vs	3·40	vs
3					3·30	s	3·24	w	3·24	m
4	..	..	..	..	2·91	w	..	..	..	..
5	..	..	..	..	..	..	..	..	..	..
6	2·75	s	2·72	m	2·75	s	2·76	m	2·74	m
7	2·52	m	2·48	m	2·53	m	2·51	m	2·49	w
8	..	..	..	..	..	..	..	..	..	..
9	2·37	s	2·34	s	2·42	m	2·40	m	2·37	m
10					2·33	m				
11	..	..	..	..	..	..	..	..	..	..
12	2·22	w	2·20	vw	2·23	vw	2·21	vw	2·20	vw
13	2·12	w	2·10	w	2·15	w	2·13	w	2·12	w
14	2·00	s	1·98	s	2·01	s	2·00	s	1·98	s
15	1·90	m	1·88	m	1·91	m	1·91	m	1·89	m

B. Aragonite Patterns (*Contd.*)

Ring number	Specimen 8		Specimen 9		Specimen 11		Specimen 12		Specimen 14	
	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.	d (Å)	Int.
1	..	..	..	..	..	..	..	..	..	..
2	3·56	s	3·40	vs	3·38	vs	3·40	vs	3·41	vs
3	3·42	m					3·27	m	3·26	m
4	..	..	3·08*	vw	..	..	..	..	2·87	vw
5	..	..	..	..	..	..	..	..	..	..
6	2·74	s	2·72	s	2·73	s	2·72	s	2·72	s
7	2·51	m	2·51	m	2·51	m	2·50	m	2·48	m
8	..	..	..	..	..	..	..	..	..	..
9	2·40	m	2·37	s	2·38	s	2·36	s	2·36	s
10	2·37	m								
11	..	..	..	..	..	..	..	..	..	..
12	2·22	vw	2·21	vw	2·21	w	2·20	vw	2·19	vw
13	2·15	w	2·12	w	2·12	w	2·11	w	2·11	w
14	1·99	s	1·99	s	1·99	s	1·98	s	1·99	s
15	1·89	w	1·90	m	1·90	m	1·88	m	1·88	m

* Probably due to a small amount of calcite present.

3. DISCUSSION

In the book by K. M. Wilbur and C. M. Yonge referred to above,[1] it is mentioned that calcite is much more common than aragonite, particularly in sea-water specimens. However, Jean Bouillon's list[2] indicates that aragonite occurs more often in shells than calcite. It is interesting that the author's results listed in Table I has shown the occurrence of aragonite in a somewhat larger percentage of his specimens than was found by Bouillon.[2] This study, however, is not extensive enough to indicate whether this is caused by the smallness of the sample survey or whether this is a particular feature of the warm, tropical regions. A more extensive and detailed study of Indian shells from this point of view would therefore be worthwhile. It is proposed to undertake such a study.

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