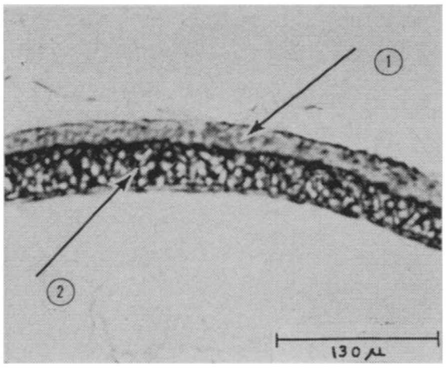

Fig. 2. Cross section of a pigmented wingtip from a cedar waxwing. Arrow No. 1 points to the dorsal pigment layer. Arrow No. 2 points to the medullary layer.

pigment migrated to the epiphasic ether layer only upon acidification with glacial acetic acid. The petroleum ether fraction was then chromatographed on a column of magnesium oxide and celite (1:1). The column was washed with petroleum ether and a single colored zone developed. Samples of the pigment were also dissolved in pyridine. The absorption spectrum of the pigment was determined in both solvents on a recording spectrophotometer (Cary, model B). The results are shown in Fig. 3. The absorption spectra show maximum peaks at 470 mμ in petroleum ether and 490 mμ in pyridine. The results agree with those of Fox (5) for astacene (3,3′,4,4′-tetraketo-β-carotene), which is the oxidation product of astaxanthin (3,3′-dihydroxy-4,4′-diketo-β-carotene) (7). On the basis, therefore, of the extraction, chromatographic, and spectrophotometric properties, we conclude that the pigment in *B. cedrorum* is astaxanthin. It should also be noted that no other carotenoid was found in the pigmented tips of this species.

Astaxanthin has been isolated, and its oxidation product astacene has been

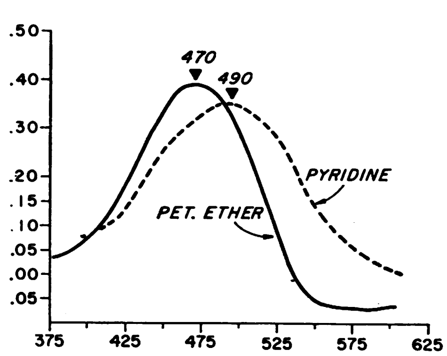

Fig. 3. Absorption spectra of astacene, from waxwings, in petroleum ether and pyridine. Ordinate, optical density; abscissa, wavelength in millimicrons.

derived, from extracts of the feathers and integument of several avian species (8). Fox (5, 9) reported these, and other carotenoids in the feathers, skin, and plasma of the roseate spoonbill (*Ajaia ajaia*), the American flamingo (*Pheonicopterus ruber*), and the James flamingo (*Phoenicoparrus jamesi*). Völker (10) and Fox (5) reported the presence of several other pigments in these species. Völker (11) has also isolated astaxanthin from the feathers of a shrike, *Laniarus atrococcineus.*

Fox (5, 6) has investigated the distribution and metabolic fate of the carotenoid pigments in the flamingo and the scarlet ibis (*Guara rubra*). The carotenoid found in highest concentration in these birds was canthaxanthin. Astaxanthin was also present but in lower concentration. In these species, the degree of pigmentation in the feathers and the integument was associated with the concentration of dietary carotenoids. The metabolic origin of astaxanthin is not yet completely understood. Fox (5) reports that even in diets containing yellow, but not necessarily red, plant carotenoids, astaxanthin was deposited in the feathers. The dietary precursor of astaxanthin and of canthaxanthin in birds has not been established. *B. cedrorum* feeds on a diet of wild fruit, flowers, and a wide selection of insects, both adult and larval. It is probable that the pigment precursor is dietary in origin.

The restriction of astaxanthin to the tips of the nine secondary wing feathers of the cedar waxwing poses several interesting questions concerning the origin, intermediary pathway and transport of the pigment, its mechanism of deposition, and its occurrence in fledglings and juvenals (12).

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Seismic Investigations of Seychelles and Saya de Malha Banks, Northwest Indian Ocean

Abstract. *Seismic refraction lines on Seychelles Bank confirm the presence of granite rock under a considerable portion of the bank. Saya de Malha Bank, also on the Mascarene Ridge, appears to be composed of volcanic rocks capped by coral. It is suggested that the two areas are structurally independent.*

In the fall of 1962, the vessels *Argo* and *Horizon* of the Scripps Institution of Oceanography were engaged in seismic refraction work in the Indian Ocean, as part of the International Indian Ocean Expedition. During this period, explosives were fired and refracted seismic waves were recorded in shallow water on Seychelles Bank and Saya de Malha Bank to determine the nature of the material making up the Mascarene Ridge.

The only previous work in the area was done during the Challenger Expedition, when one extremely short profile east of Mahé Island was shot and reported by Gaskell, Hill, and Swallow (1). The Challenger profile showed the presence of about 0.02 km of sediment or coral with a compressional-wave velocity of 2.4 km/sec; 0.13 km of material with velocity 5.58 km/sec; and beneath that, material with velocity 6.02 km/sec. Since the work was done within a few miles of the outcropping granite of Mahé, it was assumed that the material with the compressional-wave velocity of 6.02 km/sec was granitic and that with the velocity of 5.58 km/sec was probably weathered granite.

The positions of our stations LSD 20 and LSD 21 form a reversed profile; the eastern end of the profile is at the south tip of Silhouette Island, northwest of Mahé (Fig. 1 and Table 1). The line extends 42 miles west in the shallow water of Seychelles Bank. At station LSD 20, the structure is very similar to that reported previously.

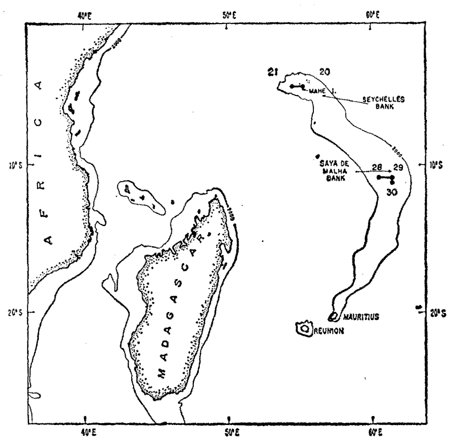

Fig. 1. Location of stations on Mascarene Ridge.

Table 1. Reversed profile from stations LSD 20 to 21. Station positions: LSD 20, 4° 34.0′S, 55°14.0′E; LSD 21, 4°31.0′S, 54° 30.0′E.

Layer	Velocity (km/sec)	Thickness (km)	
		Station 20	Station 21
Water	1.538	0.07	0.05
1	2.37	0.00 to 0.08	0.79
2	3.97	0.13 to 0.00	2.06
3	6.22		

Table 2. Reversed profile from stations LSD 28 to 29. Station positions: LSD 28, 10° 49.6′S, 60°25.2′E; LSD 29, 10°47.5′S, 61° 21.2′E.

Layer	Velocity (km/sec)	Thickness (km)	
		Station 28	Station 29
Water	1.536	0.13	0.11
1	1.72	0.19	0.56
2	3.26	1.20	0.54
3	4.36	3.05	2.51
4	5.58	4.46	3.96
5	6.81		

Table. 3. Reversed profile from stations LSD 29 to 30. Station positions: LSD 29, 10° 47.5′S, 61°21.2′E; LSD 30, 11°07.0′S, 61° 17.5′E.

Layer	Velocity (km/sec)	Thickness (km)	
		Station 29	Station 30
Water	1.536	0.11	0.12
1	1.73	0.41	0.19
2	2.68	0.98	1.03
3	4.55	1.34	2.88
4	5.26	4.77	4.29
5	6.99		

Material with a compressional-wave velocity of 5.58 km/sec was not detected, but a layer this thin may be quite discontinuous and therefore detectable only by very closely spaced shots. At station LSD 21, the material with a velocity of 2.37 km/sec (coral?) is thicker, and beneath it another layer of material (coral or volcanic rock?) with 3.97 km/sec velocity appears (Fig 2). Underlying this is material with a velocity of 6.22 km/sec, dipping down to the west. This confirms the Challenger results and shows that material with the velocity of granite is found under a large portion, probably all, of Seychelles Bank. Material with the velocity of the oceanic crust (6.8 km/sec) could be present at a depth of 8 km or more without having been detected on this profile.

Two reversed profiles on Saya de Malha Bank (our station numbers LSD 28, 29, and 30) showed a quite different structure (Fig. 3, Tables 2 and 3). A material of very low compressional-wave velocity (1.72 km/sec) is at the sea floor; 200 to 500 m of this overlies material with velocity near 3 km/sec. The upper layer is probably soft coralline mud; this was dredged at station LSD 29. The area of work is in a 110-m depression surrounded almost entirely by shallower water; this is probably an old lagoon area formerly surrounded by an extensive atoll or group of small atolls. Beneath the mud, the material with velocity near 3 km/sec is probably coral rock similar to that found at the sea floor on Seychelles Bank.

Beneath the layers with low velocity, the principal volume of the ridge is material with velocities typical of volcanic islands, 4.4 and 5.4 km/sec, as found by Raitt (*2*) at Eniwetok and by Pollard and Eaton (unpublished) at Hawaii. These rocks extend to about 8 km below sea level, well beneath the depth of the surrounding ocean, and are underlain by material with a velocity of 6.8 to 7.0 km/sec, typical of the oceanic crust.

This difference in structure between Seychelles Bank and Saya de Malha Bank may be explained by the hypothesis that there is a linear volcanic ridge (similar to the Hawaiian ridge) extending from Mauritius through Cargados Carajos shoals to Saya de Malha Bank, caused by volcanic outpourings from a line of weakness in the ocean floor. This volcanic line passes close to the Seychelles granitic block, a much older feature. Wegener (*3*) considered the Seychelles granite to be a block of continental material left behind when India and Madagascar drifted apart.

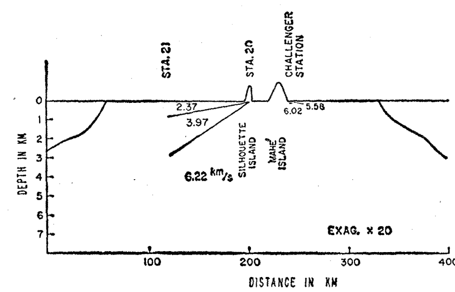

Fig. 2. East-west cross section of Seychelles Bank.

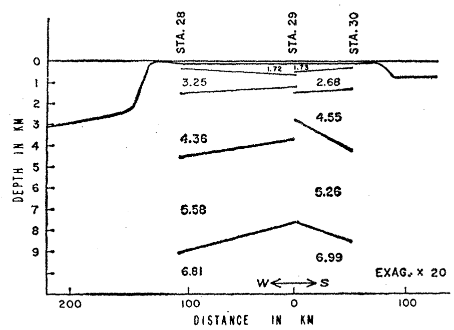

Fig. 3. Cross section along lines of shooting at Saya de Malha Bank.

More detailed information in this area would be extremely interesting; it is hoped that other groups planning seismic refraction work as part of the International Indian Ocean Expedition will examine the saddle between the Seychelles and Saya de Malha as well as the basins west and southwest of the Seychelles to determine the extent of this granitic relic (*4*).

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4. Contribution from the Scripps Institution of Oceanography, University of California, San Diego. This work was suported by the Office of Naval Research under contract Nonr 2216 (05) and by the National Science Foundation under grant 22255 as part of the International Indian Ocean Expedition. We express our thanks to Captain Marvin Hopkins and the crew of the R/V *Horizon* and to Captain Alan Phinney and the crew of the R/V *Argo* for their assistance in gathering the data; data reduction was carried out by Gloria Slack and Shirley Fisher.

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