may be isotopically lighter than the organic extracts, which contain oxygenated compounds. The mean δC^{13} value for carbonaceous substances in sediments is approximately −29 per mille, a value that is intermediate between the Soudan values.

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Igneous Rocks of the Indian Ocean Floor

Abstract. *Four dredge hauls from near the crest and from the eastern flank of the seismically active Mid-Indian Ocean Ridge at 23° to 24°S, at depths of 3700 to 4300 meters, produced only low-potassium tholeiitic basalt similar in chemical and mineralogic composition to basalts characteristic of ridges and rises in the Atlantic and Pacific oceans. A fifth haul, from a depth of 4000 meters on the lower flank of a seamount on the ocean side of the Indonesian Trench, recovered tholeiitic basalt with higher concentrations of K and Ti and slightly lower amounts of Si and Ca than the typical oceanic tholeiite of the ridge. The last sample is vesicular, suggesting depression of the area since the basalt was emplaced. Many of the rocks dredged are variously decomposed and hydrated, but there is no evidence of important chemical modification toward conversion of the lava flows to spilite during extrusion or solidification.*

The complex ridgelike features and extensive intervening basins of the Indian Ocean were first clearly indicated by surveys of the Dana and John Murray expeditions, and by the gravity-measuring traverses of Vening Meinesz (*1*). Recent oceanographic investigations undertaken by the International Indian Ocean Expedition, 1960–1965, have further clarified several major geological features, especially its fascinating patterns of both elongated and bifurcated faulted ridges, the large "plateaus" and irregular deeps, and the texture of the deep-sea floor (*2*). Figure 1 is a simplified map of the Indian Ocean showing one version of the gross patterns of the ridge complex shallower than 4000 m, and the locations of islands and dredge samples discussed in this report.

Early petrologic studies in the Indian Ocean were confined to the volcanic islands which lie along and flank the Indian Ocean ridges (*3*). These islands include Mauritius, Rodriguez, Réunion, New Amsterdam, St. Paul, Crozet, and the Kerguelen Archipelago (Fig. 1). Each consists of one or more variously coalescing, sometimes fragmented, volcanic cones. Continuing studies, ranging over more than a century, have shown that the dominant volcanic rocks capping these islands and the higher submarine volcanoes are alkali basalts, which are commonly accompanied by subordinate, derivative members of the alkali series, especially andesine- and oligoclase-andesites, trachytes, and more rarely phonolites and rhyolites (*4*). Olivine-rich (picritic) basalts are found on some of the islands; tholeiitic basalts with low concentrations of potassium, high concentrations of calcium and silica, and high ratios of calcium to magnesium are extruded, notably on Mauritius and Réunion islands (*5*). Small inclusions of magnesium-rich peridotite and pyroxene amphibolite occur in the alkali basalts and in associated beds of ash, but these inclusions represent less than 0.1 percent of the exposed rock. The alkali-rich basalts comprise over 90 percent of the igneous rocks of most islands.

These relative abundances of rock types from the exposed parts of the volcanic cones along the Indian Ocean ridge systems are similar to those from volcanic islands of the Atlantic and Pacific oceans, where alkali basalts and subordinate members of the alkali series also predominate. In the Atlantic and Pacific, olivine-rich basalts are common but volumetrically subordinate. Tholeiitic basalts occur only rarely, except in the several major oceanic rift-island systems such as Hawaii and Iceland, where they are abundant (*6*).

The alkali basalts which are typical and predominant constituents of the higher oceanic volcanoes are characterized, among the basalts, by relatively high concentrations of K, Na, Ti, and P and a high ratio of Fe^{3+} to Fe^{2+}. They also contain distinctly higher concentrations of Ba, La, Nb, Pb, Rb, Th, U, and Zr, and higher ratios of K to Rb, Sr^{87} to Sr^{86}, and Pb^{206} to Pb^{204} than are found in picritic and tholeiitic basalts of the oceans. Detailed discussions of the chemical characteristics of oceanic basalts, including abundances of minor and trace elements and of the isotopes of strontium and lead, are being published separately (*7*).

The dominance of alkali-rich basalts on readily accessible oceanic islands caused early petrologists to suggest that these rocks were characteristic of the entire oceanic crust (*8*). It was in the light of this petrologic concept that Wiseman (*9*) examined and first described dredge hauls from the more deeply submerged parts of the ridge complex in the northwestern Indian Ocean. The location of Wiseman's samples is shown in Fig. 1 (position *JM*). Wiseman recognized that the ridge rocks were not typical alkali basalts like those found on the islands of the Indian Ocean. He noted that the dredged basalts were relatively uniform in composition and that they contained extremely low concentrations of potassium, relatively high concentrations of sodium and silica, and moderate to low ratios of Fe_2O_3 to FeO, especially in their glassy parts. The differences in composition between the basalts of the submerged ridge and those from the islands naturally perplexed Wiseman. He both suggested and rejected close interrelationships between the island and the submarine basalts (*9*).

Following Wiseman's studies, there ensued three decades during which few rocks were dredged from the deeper parts of the Indian Ocean or other oceans, and none were described and discussed in detail. However, several close students of Hawaiian geology either implied or stated that tholeiitic basalts were common in the central Pacific and that the alkali series of Hawaii appeared to be largely younger than, and probably derivative from, a tholeiitic root of the great Hawaiian Rift (*10*).

Recent studies in the Atlantic and Pacific oceans suggest that a most unique, low-potassium, tholeiitic basalt (oceanic tholeiite) is the dominant igneous rock of the oceans (*11–14*). The alkali basalts so characteristic of the higher volcanoes appear to be derived from oceanic tholeiites, which are the most primitive, least radiogenic basalts yet found in the earth's crust (*7*).

Because of the scarcity of samples of igneous rocks from deeply submerged features of the Indian Ocean, Expedition Dodo of the Scripps Institution of Oceanography undertook in 1964 a series of dredge hauls along a rudely arcuate ENE–WSW profile across the median ridge of the Indian Ocean near latitudes 23° to 24°S (Figs. 1 and 2). Four hauls of bedrock were obtained at depths ranging from 3700 to 4300 m in three portions of the ridge environment. One haul came from near the central, highest portion of the ridge; two from the eastern, irregular "foothills"; and one from generally oceanic depths well off the east side of the ridge (Fig. 2). Later in the expedition a fifth dredge haul, from depths of approximately 3800 to 4300 m, was made on the flank of a seamount on the ocean side of the Indonesian Trench, southwest of Sumatra (Fig. 1, sample D232).

In the mid-ocean region sampled on the expedition, the median ridge is extremely irregular in profile both across and along its northerly trend. Figure 2, prepared from echo-sounding records, shows the topography in an exaggerated fashion. Here the ridge, or more properly the southeast branch of the Mid-Indian Ocean Ridge complex, is 400 to 500 km wide and includes 8 to 12 major peaks and numerous minor pinnacles on each crossing. The depths of a few peaks are 2100 to 2400 m. However, the general range of ridge depths is 3500 to 3900 m, and local depressions or canyons reach 4200 to 4300 m. Such depressions are only 1 to 3 km wide and show only minor evidence of sediment fill. On the flanks of the ridge, pinnacles decrease in height but increase in steepness and number. Steep-walled, fairly linear deeps which may be fault troughs intersect or roughly parallel the ridge. These depressions extend from tens to hundreds of kilometers off the ridge at depths 400 to 500 m greater than the 4000 to 4300 m depth of the sea floor and its abyssal hills.

Table 1. Compositions of basalts from the Mid-Indian Ocean Ridge.

Oxide	Amount present (%)						
	D113 A1*	D113 D1*	D114 A†	D115 B‡	D115 L‡	D143 A§	D 143 B§
SiO_2	50.30	50.20	49.52	49.62	48.77	50.04	49.98
TiO_2	1.38	1.35	1.31	1.13	0.76	1.29	1.37
Al_2O_3	15.88	16.91	18.01	16.48	21.09	16.91	16.70
Fe_2O_3	1.61	1.36	2.12	4.14	2.68	3.08	1.45
FeO	7.88	7.30	5.80	4.53	3.89	4.98	6.64
MnO	0.09	0.15	0.18	0.18	0.10	0.14	0.18
MgO	7.56	7.65	6.83	7.25	5.47	7.38	7.52
CaO	11.43	11.26	11.70	11.35	13.22	10.86	11.10
Na_2O	2.69	2.64	2.81	3.03	2.66	3.51	2.97
K_2O	0.17	0.18	0.19	0.24	0.11	0.25	0.18
H_2O^+	.41	.59	.68	.71	.79	.85	.82
H_2O^-	.27	.24	.54	1.31	.45	.57	.76
P_2O_5	.07	.12	.04	0.07	.11	.10	.10
Total	99.74	99.95	99.73	100.04	100.10	99.96	99.77

* D113 A1 and D113 D1, analyses of the glassy margins of two pillows; interiors of the pillows are porphyritic basalt with phenocrysts of calcic plagioclase, and groundmass is glassy to fine-grained, with abundant plagioclase crystallites; location, 23°20.6′S, 74°56.5′E; depth, 4100 m. † D114 A, porphyritic basalt with phenocrysts of calcic plagioclase (bytownite), groundmass composed largely of labradorite and clinopyroxene, rare small vesicles; location, 24°08.6′S, 72°26.6′E; depth, 4000 m. ‡ D115 B and D115 L, porphyritic basalt with phenocrysts of calcic plagioclase, groundmass largely plagioclase and calcium-rich pyroxene, rare tiny vesicles; location, 24°02′S, 70°14.1′E, depth, 3700 m. § D143 A and D143 B, porphyritic basalt with phenocrysts of labradorite, groundmass composed of plagioclase, clinopyroxene, and olivine; 23°43.7′S, 72°42.6′E, depth, 4300 m.

Table 2. Partial analyses of additional basalts from the Mid-Indian Ocean Ridge. Samples are from the dredge hauls listed in Table 1.

Oxide	Amount present (%)			
	D113 A2*	D113 D2†	D114 B‡	D143 P§
SiO_2	49.61	48.20	49.33	49.62
TiO_2	1.20	1.46	1.39	1.50
Na_2O	2.75	2.82	2.77	3.09
K_2O	0.23	0.19	0.24	0.30
P_2O_5	.08	.04	.12	.14

* D113 A2, porphyritic interior of pillowed basalt (sample D113 A1, Table 1, is the glassy outer margin). † D113 D2, porphyritic, plagioclase-rich interior of pillowed basalt (sample D113 D1, Table 1, is the glassy outer margin). ‡ D114 B, plagioclase-rich basalt from dredge haul D114. § D143 P, porphyritic, labradorite-rich basalt with groundmass of plagioclase, clinopyroxene, and olivine.

No obvious central "rift valley" has been traced along this portion of the median ridge. On most profiles the central 200 to 300 km seem to contain larger peaks which are separated by depressions up to 15 km in width; haul D115 was recovered from one such peak. Plots of earthquake epicenters show that in these latitudes the median ridge complex is relatively quiet at present, although earthquakes have occurred in this rifted region. North of 20°S this same median ridge is seismically more active. There is also considerable seismic activity on the NE-trending ridge which presumably intersects the median ridge just west of the area sampled (Fig. 1). The near-absence of sediment-filled depressions in the region makes penetrations with heat-flow equipment difficult. A few measurements from Expedition Monsoon (1960) and Expedition Dodo in the vicinity of the median ridge show values for heat flow somewhat higher than the oceanic average (*15*). These characteristics, as well as the occurrence of only volcanic shards in cores taken nearby by the Monsoon Expedition, and the little-weathered lavas of the dredge collections, indicate abundant recent volcanism.

The compositions of seven basalts from the four dredge hauls made at intervals across the Mid-Indian Ocean Ridge are listed in Table 1. Partial analyses of four more basalts from these localities are listed in Table 2. All of these basalts are similar to the oceanic tholeiites recently recovered from widely separated, submarine segments of both the Atlantic and Pacific ridge and rise systems (*11–14*).

The close compositional similarities of oceanic tholeiites from the oceans, and the contrasting compositions of the average alkali-rich basalts from the islands of the Indian Ocean, are indicated in Table 3. This table contains the compositions of average oceanic tholeiites dredged from the Indian Ocean median ridge in the latitudes 22° to 23°S, the East Pacific Rise, and the Mid-Atlantic Ridge. The average of four basalts described by Wiseman from the Carlsberg Ridge is tabulated in Table 3, column 2 (*9*). A single sample of glassy basalt reported by Korzhinsky (*16*) from the Indian Ocean appears in column 3. Column 6 is an average of 42 published analyses of alkali-rich basalts from islands in the Indian Ocean.

In compiling the averages of oceanic tholeiites from the several oceans we have used only the analyses of essentially unaltered basalts that are not highly porphyritic. This selection of the data indicates the close similarities in composition of the fresh, glassy, and more equigranular oceanic tholeiites which are most likely to represent the compositions of primary magma. The marked departures of individual samples from the average compositions of the submerged ridge basalts that are listed in Table 3 are found in oceanic tholeiites that are (i) highly porphyritic, especially those containing abundant phenocrysts of plagioclase feldspar, (ii) variously altered by sea water, and (iii) recovered from the deeply submerged flanks of large volcanic cones, rather than from extensive submarine flows, fault scarps, or abyssal hills.

Compositional variations induced in primary magmas by growth and redistribution of phenocrysts are well known. Plagioclase is the least dense of the major constituent silicates in basalt, and early formed phenocrysts of labradorite or anorthite may either rise or sink more slowly in the magma than the denser olivine and pyroxene. One of the distinguishing aspects of the oceanic tholeiites is their enrichment in calcic plagioclase relative to the tholeiites which are characteristic of the Hawaiian and Icelandic regions (*6*). This is reflected especially in higher concentrations of alumina and calcium. In the oceanic tholeiites from the Indian Ocean Ridge, Al_2O_3 varies from almost 16 to more than 21 percent by weight, depending upon the amount of calcic plagioclase present as phenocrysts (Table 1); CaO varies from about 10.9 to 13.2 percent (Table 1). Specifically, basalt D113 Al is nonporphyritic and fine-grained to glassy, whereas D143 A is porphyritic. The phenocrysts in D143 A consist almost entirely of labradorite.

Similar variations in calcium and alumina are found in the oceanic tholeiites of the Atlantic and Pacific oceans. The highest concentrations invariably occur in markedly porphyritic

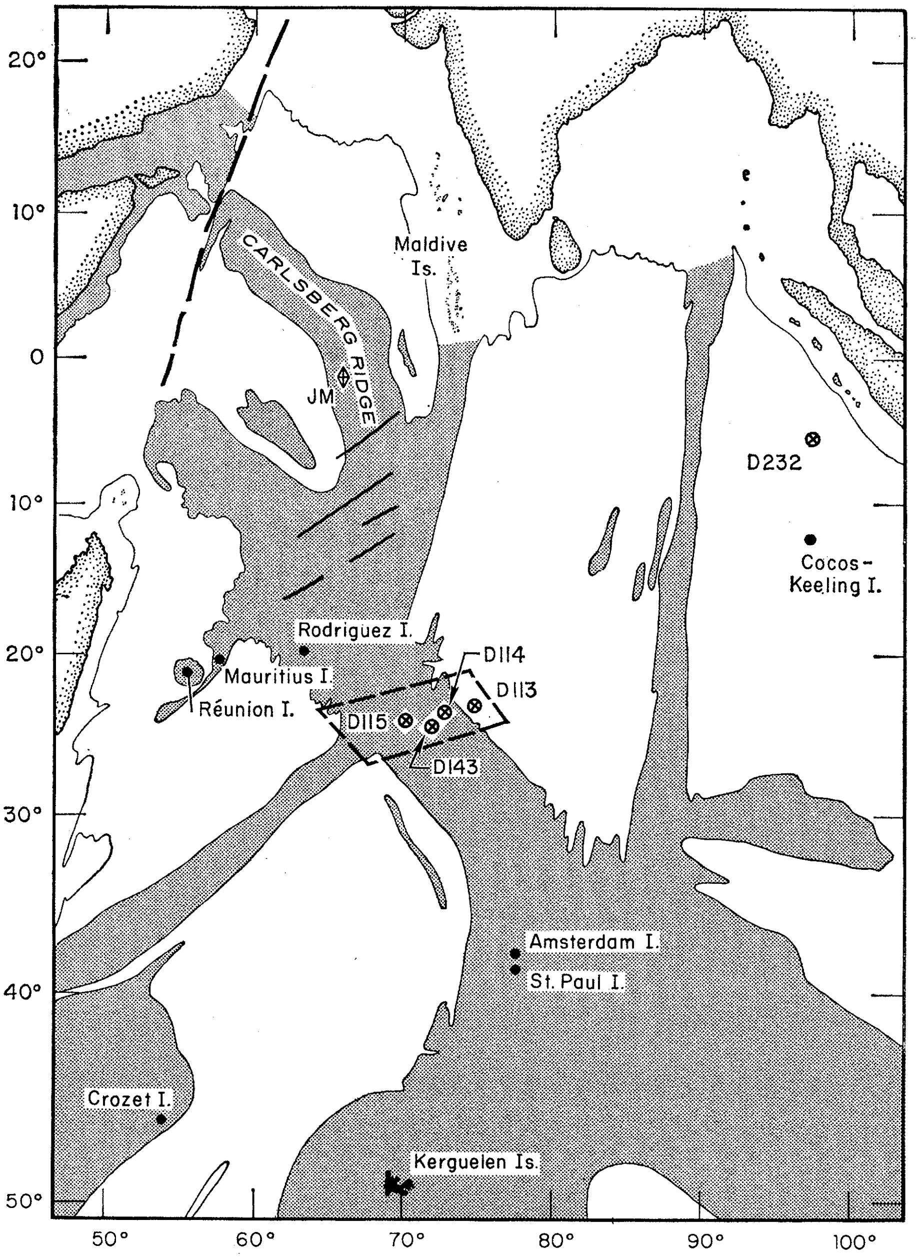

Fig. 1. Index map of the Indian Ocean. Oceanic ridges and associated rises shallower than 4000 m are stippled [after Heezen and Tharp (*2*)]. Islands are represented by black dots. The dashed line approximates the Owen Fracture Zone (*21*) and the heavy solid lines north of Rodriguez Island are inferred cross fractures on the median ridge. The diamond symbol *JM* represents the site of igneous rocks dredged by the John Murray Expedition (*1*). The crossed circles are sites of dredging by Expedition Dodo. The region within the dashed quadrangle is enlarged in Fig. 2.

Table 3. Average compositions of basalts from the Indian, Atlantic, and Pacific Ocean Ridge and Rise systems and of basalts from islands in the Indian Ocean (calculated water-free).

Oxide	Amount present (%)					
	1*	2†	3‡	4§	5‖	6¶
SiO_2	50.65	51.81	51.13	50.25	49.78	47.67
TiO_2	1.36	1.88	0.35	1.56	1.29	2.66
Al_2O_3	17.09	15.56	15.20	16.09	16.92	15.72
Fe_2O_3	1.66	3.56	1.16	2.72	1.94	4.51
FeO	7.00	6.39	7.64	7.20	7.32	7.86
MnO	0.15	0.17	0.18	0.19	0.16	0.30
MgO	7.49	7.10	10.45	7.02	8.18	6.75
CaO	11.52	9.35	11.89	11.81	11.34	9.68
Na_2O	2.82	3.87	1.81	2.81	2.77	3.05
K_2O	0.18	0.11	0.19	0.20	0.16	1.35
P_2O_5	.08	.20	n.d	.15	.14	0.45

* Average of four analyses of oceanic tholeiite from the Mid-Indian Ocean Ridge (Table 1: D113, A1, D113 D1, D114 A, and D115 B). † Average of four analyses of tholeiitic basalt from the Carlsberg Ridge, Indian Ocean (*9*). ‡ Tholeiitic basalt from an abyssal hill, Indian Ocean: 26°18′S, 89°56.5′E; depth, 4900 m (*16*); n.d., not determined. § Average of six analyses of oceanic tholeiite from the East Pacific Rise (*11–12*). ‖ Average of seven analyses of oceanic tholeiite from the Mid-Atlantic Ridge. Detailed analyses are given variously by Engel and Engel (*11*), Nicholls *et al.* (*13*), and Correns (*20*). ¶ Average of 42 published analyses of "alkali" basalt from islands of the Indian Ocean.

basalts with calcic plagioclase as the only or predominant phenocryst (*11–14*). The aluminous and calcium-rich tholeiites are either products of partial melting, related to depth of derivation of the primary melt (*17*), or the extrusions of oceanic tholeiites from the upper portions of partially crystallized magma in large chambers in the mantle.

The average of the four basalts from the Carlsberg Ridge, Indian Ocean, that Wiseman analyzed (Table 3, column 2) indicates the low K_2O, high ratios of Na to K, and high silica characteristic of oceanic tholeiites from other localities (Table 3, columns 4 and 5). The high concentrations of Na_2O and the low value for CaO in Wiseman's analyses appear, however, anomalous. For example, the average percentages of Na_2O (3.87) and CaO (9.35) calculated from the four Wiseman analyses seem inconsistent with the remarkably low K_2O (0.11). Very possibly these and other differences in the Wiseman average from the averages in other columns in Table 3 are due to differences in analytical methods.

Variations that are induced in composition of oceanic basalts by submarine alteration are illustrated by the compositions of the three oceanic tholeiites D115 L, D143 A, and D143 B taken from the median ridge (Table 1). The most obvious incipient effects of alteration indicated in these analyses are increases in amounts of water and in the ratio Fe_2O_3 to FeO, which may approach or even exceed 1. Total iron and magnesia frequently decrease slightly, and manganese increases, with increasing alteration, but there is no consistent change in amounts of alkalis or silica. Petrographically the alteration is evidenced by the appearance of palagonite, limonite, hematite, and calcite which replace olivine, pyroxene, magnetite, and small amounts of the constituent plagioclase.

Many samples of pillowed, tholeiitic basalts from the median ridge have glassy to microcrystalline margins which have resisted hydration, oxidation, and other types of weathering far more than have the coarser-grained interior parts of the pillows, many of which are moderately to strongly altered.

Analyses were undertaken to see if there are systematic or important differences in amounts of sodium and potassium in the margins of these pillow lavas, compared with their least altered interior parts. These are illustrated by the pairs D113 A1 and D113 A2 and D113 D1 and D113 D2 (Tables 1 and 2). Samples D113 A1 and D113 D1 (Table 1) are of

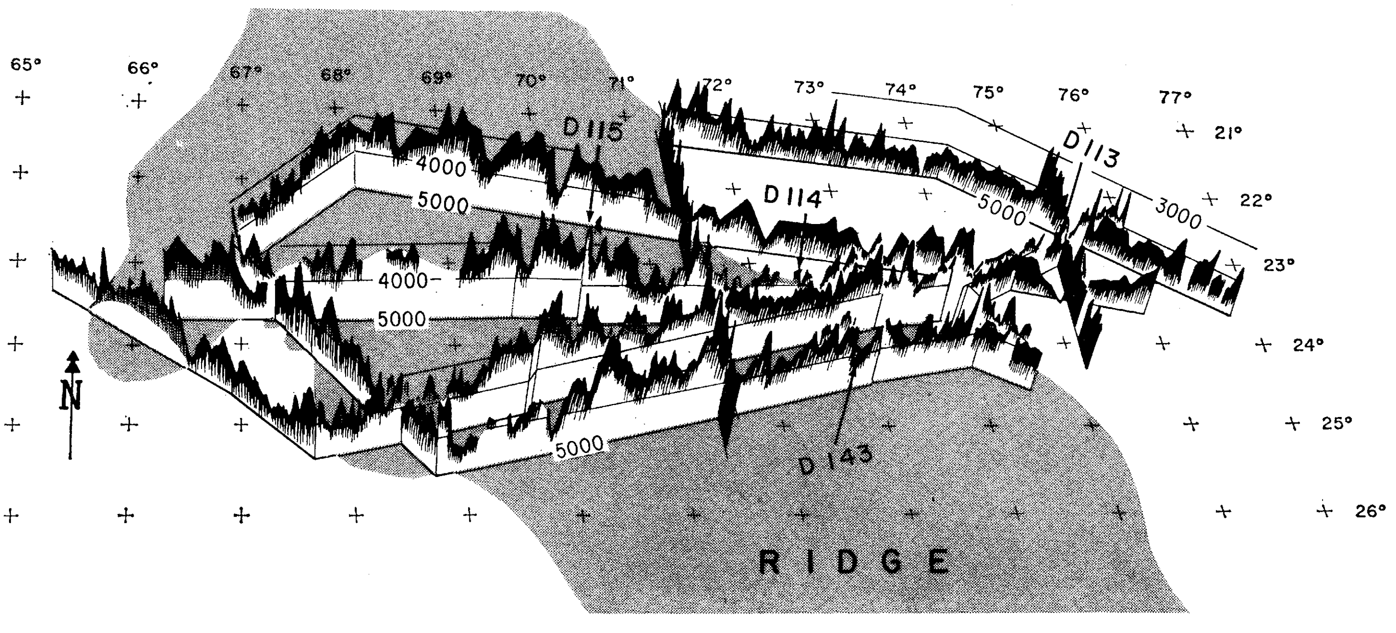

Fig. 2. Intersecting profiles of the Mid-Indian Ocean Ridge in the area of the four dredge localities shown in Fig. 1. The vertical exaggeration is ×50, and the three horizontal lines are respectively the 3000-, 4000-, and 5000-meter isobaths.

Table 4. Composition of vesicular basalt D232 dredged from near the base of a submarine volcano in the eastern Indian Ocean. Sample is porphyritic with phenocrysts of labradorite in a matrix of fine-grained pyroxene, plagioclase, and rare opaque oxide. Vesicles are spherical to slightly flattened and comprise about 20 percent of the rock. A partial analysis of another fragment from the same dredge haul yields: TiO_2, 1.47; Na_2O, 2.93; K_2O, 0.81; P_2O_5, 0.22.

Oxide	Amount present (%)
SiO_2	48.37
TiO_2	1.63
Al_2O_3	16.18
Fe_2O_3	6.07
FeO	2.98
MnO	0.18
MgO	6.20
CaO	10.08
Na_2O	3.04
K_2O	0.85
H_2O^+	1.76
H_2O^-	2.24
P_2O_5	0.30
Total	99.88

the external glassy margins of pillows, and samples D113 A2 and D113 D2 (Table 2) are of crystalline cores some 25 to 30 cm inside the pillows. The glassy margins of the basalt pillows show very slight to negligible enrichment in Na and K and a complementary slight decrease in SiO_2. Other differences are not consistent, and it is clear that the surficial reactions of the basalt flow with sea water do not produce large differences in the composition of the constituent basalt.

The basalt D232 dredged southwest of Sumatra is illustrative of compositional variations in tholeiitic basalts found on the lower flanks of deep submarine volcanoes. These basalts may be designated as oceanic tholeiites with slight alkali affinities. Specifically, silica is slightly lower than it is in the average oceanic tholeiite; potassium and the ratio Fe_2O_3 to FeO are much higher; and titanium, phosphorus, and total alkalis are slightly higher. We have found three somewhat similar basalts on the lower flanks of large submarine volcanoes in the Pacific whose apical parts are largely alkali-rich basalt. Muir and Tilley (*14*) also describe tholeiites with "alkaline affinities" from "lava flows from large volcanoes situated on opposite sides of a valley" in the Mid-Atlantic Ridge, and Engel and Chase (*18*) have studied a typical example from the Cocos Ridge, Pacific Ocean.

We have noted the correlation between composition of basalt and the form, height, and possibly rate of construction of volcanic edifices in the oceans (*7*). Typical alkali basalts and the alkali series appear to be confined largely or entirely to the apical parts of the higher volcanoes. These field relations, coupled with a large amount of supporting chemical data, suggest that the alkali series is derived from a parental oceanic tholeiitic magma within, and not far below, the higher volcanoes. Gravity appears to be the prime factor in differentiation, causing crystal segregation according to relative densities and also the upward transfer of alkalis in aqueous solution. By this hypothesis there should necessarily be melts intermediate between primary tholeiitic magma and derivative alkali basalts, or accidental mixes of the two that may breach lower flanks of the volcanoes and occur there as mantling flows. We suggest that the basalt D232 (Table 4) from the eastern Indian Ocean and the basalts described by Muir and Tilley (*14*) and by Engel and Chase (*18*) from, respectively, the Atlantic and the Pacific oceans are of this type.

Basalt D232, which was dredged from exposures 4000 m deep on the flank of a large volcano, contains about 20 percent vesicles, many almost spherical, with diameters up to 1 mm. Moore has emphasized that in the Hawaiian region there is a fairly systematic decrease in size and abundance of vesicles of basalts with depth of water (*19*). We have also found this to be true for most other regions dredged in the Atlantic and Pacific oceans. Usually basalts extruded at depths of 4000 m or more are devoid of vesicles and have a density of about 3 to 3.1. The low density and abundance of large, round vesicles in the basalt from the eastern Indian Ocean suggest that this region may have sunk at least a kilometer, possibly several kilometers, since the basalt was extruded. While some change in depth would be due to addition of water to the ocean, the position of the seamount may be significant. It lies on the northern edge of the deep Wharton Basin and rises from a discontinuous low swell or rise seaward of the Indonesian Trench. It is very possible that trench-forming processes have caused the entire bordering sea floor to be depressed.

Most submarine basalts dated by radiometric methods show increasing amounts of alteration with age. The extent of the alteration of the basalt D232 of the Indian Ocean suggests the age of extrusion, and hence the date of deep submersion, is not in excess of 30 million years.

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20 August 1965

Ribosomes: Analysis by Cesium Sulfate Gradient Centrifugation

Abstract. *Ribosomes from the cytoplasm of a mammalian tissue, HeLa cells, were partially purified and then concentrated into a zone by prolonged centrifugation in* Cs_2SO_4 *solution (density, 1.43 grams per milliliter). Ribosomal preparations treated with bentonite prior to density-gradient centrifugation showed single peaks after centrifugation. Material recovered from the peaks represented aggregates of the original 74S particle.*

Sedimentation analyses of ribosomes have been performed with sucrose gradient centrifugation, which separates particles according to mass. Although analyses of ribosomes by equilibrium density-gradient centrifugation are desirable, since this technique provides resolution based on buoyant density, few studies have been reported. This situation is due to the instability of most ribosomal preparations at the concentration of CsCl needed to provide the proper buoyant density. However, ribosomes from *Escherichia coli* are concentrated into zones (that is, form bands) during density-gradient centrifugation in CsCl when sufficient magnesium ion is present (*1*, *2*). Attempts in this laboratory to produce similar results with ribosomes from HeLa cells in CsCl with various concentrations of Mg ions have been unsuccessful. That Cs_2SO_4 might be used as a band-forming medium for ribosomes was suggested by the fact that RNA itself remains sufficiently hydrated to form bands in a solution of this salt (*3*), and hence the ribosomal RNA–protein linkages might remain protected from salt dissociation because of retention of a water shell.

HeLa cells were grown in Eagle's medium for spinner culture with 5 percent horse serum, collected by centrifugation, and treated at 4°C as follows. Cells were washed first in unbuffered saline; then in 0.35*M* sucrose with 4 m*M* magnesium acetate and 25 m*M* KCl, *p*H 7.6; and finally in 0.35*M* sucrose with 1 m*M* magnesium acetate, 1 m*M* spermine, and 5 m*M* KCl, *p*H 7.6. The cells were then suspended in four volumes of 0.1 percent Tween-80 solution containing 0.25 m*M* magnesium acetate and 0.25 m*M* spermine at *p*H 8.3 and homogenized with a Teflon pestle at 5000 rev/min for 5 minutes. Nuclei were removed by centrifugation, and the homogenate was adjusted to 0.5*M* sucrose and treated with 1/10 volume of 5 percent sodium deoxycholate for 30 minutes. The homogenate was then mixed with a concentrated solution to bring it to 2 m*M* magnesium acetate, 80m*M* NaCl, 6m*M* $NaHCO_3$ and 4m*M* tris-HCl (*p*H 8.3, buffer A) and centrifuged at 5000 rev/min for 2 minutes. Sucrose (1.3 g per 10 ml of homogenate) was added, and the material was centrifuged (Servall SS-1) at 12,000 rev/min for 10 minutes. The supernatant was removed and homogenized at 25,000 rev/min for 270 minutes. The pellet was suspended in 10 ml of buffer A, and large cell fragments were removed by centrifugation at 25,000 rev/min for 20 minutes. The supernatant was concentrated by dialysis against Aquacide (Calbiochem). This concentrated solution contained about equal amounts of protein and RNA, and it was our partially purified ribosomal preparation. Further purification was accomplished by Sephadex-G200 filtration in buffer A and by sucrose-gradient centrifugation. Cesium sulfate (99 percent minimum purity) was purchased from Kawecki Chemical Co. and purified (*4*). Ribosome solutions were rapidly mixed with concentrated Cs_2SO_4 solution (*p*H 8.6, containing Mg ion and tris-HCl) and poured into 5-ml centrifuge tubes. The solution volume of 2.5 ml was overlaid with paraffin oil. After centrifugation in a Spinco model L, the tube was punctured and two-drop fractions were collected. After addition of 90 μg of carrier (RNA and albumin) to a sample, the mixture was precipitated with cold 8 percent trichloroacetic acid; the precipitate was collected on a Millipore filter and washed twice with 5 ml of cold distilled water and dried at 80°C. The radioactivity was then measured in a Tri-Carb scintillation spectrometer.

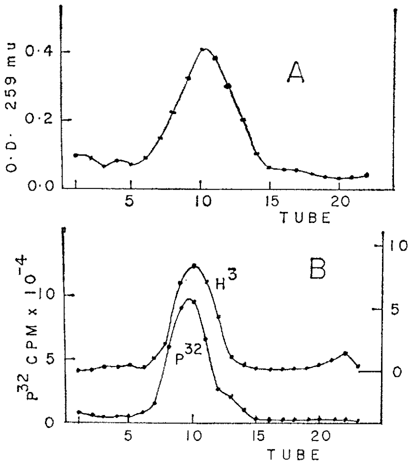

Fig. 1. Distribution of ultraviolet-absorbing and radioactive material in ribosomes. (*A*) Partially purified ribosomes (2.5 ml) were treated with bentonite; Cs_2SO_4, density 1.43 g/ml; 10 m*M* Mg ion; 39,000 rev/min, 34 hours. (*B*) Bentonite-treated ribosomes (2.5 ml) were labeled with phosphate-P^{32} and valine-H^3; Cs_2SO_4, density 1.43 g/ml; 10 m*M* Mg; 39,000 rev/min, 34 hours. Solution density increases from right to left. *CPM*, counts per minute; *O.D*, optical density.

Bentonite, used for ribosomal purification, was prepared according to Fraenkel-Conrat, Singer, and Tsugita (*5*). Bentonite treatment of ribosomal preparations from bovine pancreas removes adsorbed enzymes, including ribonuclease (*6*), and produces stable particles. Partially purified HeLa

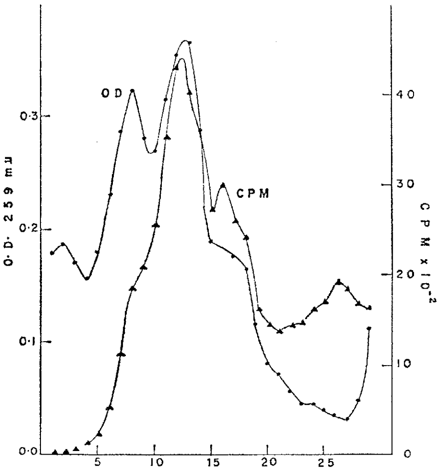

Fig. 2. Distribution of radioactivity in ribosomes not treated with bentonite. A 2.5-ml mixture of radioactive ribosomes labeled with lysine-H^3 and nonlabeled ribosomes was centrifuged in Cs_2SO_4 (density, 1.43 g/ml) containing 10 m*M* Mg ion; 38,000 rev/min for 96 hours.