blood from the spacious lacunae of the excretory organ to the gills. In this case their function is to complete the circulation of the blood which has lost arterial pressure after having passed through the lacunae of the viscera and into the excretory organ. In the oyster essentially the same condition obtains, save that, as in other Lamellibranchs, the mantle surfaces probably function largely in respiration, while the gills pump the food- and oxygen-bearing water. Thus the gills are primarily feeding organs, rather than respiratory. The gill hearts, in the oyster, pump blood into the highly vascular mantle, where aeration is accomplished, and also, through relatively small vessels, into the gills. The term, *gill hearts,* may be considered to apply to the oyster, in spite of these matters, because of homology with the Cephalopod organs.

The circulatory system of the oyster (*O. gigas*) consists of two parts, very incompletely separated. Blood from the ventricle of the heart is distributed through two large arteries: the posterior aorta, supplying chiefly the adductor muscle; and the anterior aorta, which runs forward, giving off branches into the visceral mass, and at the anterior end opening into a large vessel which divides both dorsally and ventrally into a pair of marginal pallial arteries which run completely around the border of each mantle lobe. That is, the dorsal pallial artery of each mantle lobe is continuous with the ventral pallial artery of the same lobe through the marginal artery. Venous blood from the adductor muscle and viscera is collected in the lacunae of the paired excretory organs, which apparently do not communicate directly with the auricles, as some investigators have thought. From the blood spaces of each kidney a large vessel, the accessory heart, pumps blood directly into the corresponding marginal artery, entering slightly anterior to the posterior insertion of the gills, along which runs a vessel connecting the two marginal arteries together and giving off branches to the gills. Thus the ventricle pumps blood into the marginal arteries from anteriorly while the accessory hearts pump blood into the same arteries near the posterior ends of the gills. The blood in the marginal arteries is subjected to pressure from two directions. In addition, the accessory hearts give off along their course small branches to the adjacent mantle.

The marginal arteries send out branches both distally and proximally into the mantle tissue and the blood is collected by lacunae and veins leading directly to the auricles of the heart. Veins from the gills also empty into the auricles. In this manner the blood returning to the heart, after aeration in the mantle and gills, consists in part of that which has been purified by the excretory organs and in part of systemic blood. The two communicating systems are readily demonstrated by injecting a colored fluid either into the ventricle, from which it goes throughout the marginal arteries, or into one of the accessory hearts, from which it goes into both of the marginal arteries and gills. The marginal artery, then, receives both arterial and venous blood, both purified (by the excretory organ) and unpurified blood.

It is considered possible that the accessory hearts described above may also be found in some other Lamellibranchs, though in most it would probably be difficult to observe the action of the organs.

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IS THE COLOR OF THE NATURAL RUBY DUE TO IRON?

IT is a well-known fact[1] that synthetic ruby must contain at least 1½ to 2½ per cent. chromic oxide in order to approximate the color of the natural gem; furthermore, it has already been shown[2] that there is not sufficient chromic oxide in natural ruby to account for its depth of color. The literature contains many analyses[3] of both natural and synthetic rubies which show that the two are chemically dissimilar; synthetic rubies contain chromic oxide but no ferric oxide, whereas natural rubies contain significant amounts of the latter in addition to the former; on the other hand, no distinction seems to be made between the two coloring agents in the naturally occurring mineral.

It was accordingly of interest to examine a number of natural rubies for the purpose of determining both the chromium and the iron content of the same specimen, of correlating their color with the amount of pigmenting oxide found and of deciding whether there is a definite ratio between the amounts of iron and of chromium oxides present.

After crushing the rubies to pass a 200-mesh sieve, and fusing them with potassium acid sulfate in the ratio of 15:1,[4] the iron was first separated by means of cupferron[5] and was ignited to the oxide. In order

[1] A. Verneuil, Compt. rend., 135: 791, 1902; G. F. H. Smith, "Gemstones," p. 117, London, 1923; E. Frémy, "Synthèse du Rubis," p. 1, Paris, 1891; C. Doelter, "Farben der Mineralien," p. 28, Braunschweig, 1915.

[2] Jacob Papish and Wm. J. O'Leary, *Jour. Ind. Eng. Chem.*, Anal. Ed., 3: 11, 1931; Wm. J. O'Leary and Jacob Papish, *Am. Mineral.*, 16: 34, 1931.

[3] L. Smith, *Ann. des mines,* [4], 18: 288, 1850; J. Terreil, *Compt. rend.*, 59: 1047, 1864; Malaguti, *Compt. rend.*, 4: 1000, 1837; A. Liversidge, "Minerals of New South Wales," p. 134, Sydney, 1882; K. Pfeil, Inaug. Dissert., Heidelberg, 1901; Centr. Mineral., 145, 1902; G. P. Tschernik, *Z. Krist.*, 55: 191, 1915.

[4] Wm. J. O'Leary and Jacob Papish, *Am. Mineral.*, 16: 34, 1931.

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to check the quantitativity of the iron determinations in the presence of large amounts of aluminum and small amounts of chromium, known mixtures containing all three of these elements were prepared and analyzed. The iron was added from a previously standardized solution of ferrous ammonium sulfate, and the chromium was added as potassium chromium sulfate, to one gram of dry aluminum oxide or a proportionate weight of ammonium alum; in this way, mixtures were prepared in which the Al_2O_3 contained 0.5, 1.0 and 1.4 per cent. Fe_2O_3, with a constant 0.2 per cent. Cr_2O_3. When aluminum oxide was used, a fusion was made with potassium hydrogen sulfate in the ratio of 15:1; when ammonium alum was used, the same amount of flux was added without fusing. The results of these preliminary analyses are listed in Table I.

Spectrographic examination of the Fe_2O_3 obtained by precipitating once with cupferron showed the presence of small amounts of aluminum, which led to the high results shown in the second column of Table I; consequently, the iron had to be reprecipitated before final weighing. Reprecipitation was effected by washing the ignited precipitate into a beaker, adding 25 cc of concentrated sulfuric acid, heating until solution was complete, diluting and then precipitating again with cupferron in the usual way. This procedure gave the results listed in the third column of Table I; it was found that further reprecipitation does not change the results beyond experimental error.

TABLE I

RECOVERY OF IRON FROM MIXTURES CONTAINING KNOWN AMOUNTS OF ALUMINUM, CHROMIUM AND IRON

Gm Fe_2O_3 added	Gm Fe_2O_3 recovered	
	1st precipitation	2nd precipitation
0.0100	0.0130	0.0099
0.0100	0.0114	0.0102
0.0100	0.0118	0.0103
0.0140	0.0156	0.0140
0.0140	0.0189	0.0143

TABLE II

CHROMIUM AND IRON CONTENT OF RUBIES

Ruby no.	Place of origin	Chromium content		Iron content		Per cent. pigmenting R_2O_3	Color
		Per cent. Cr	Per cent. Cr_2O_3	Per cent. Fe	Per cent. Fe_2O_3		
1	Clay County, N. C.	0.136 0.139	0.201 0.203	0.44 0.44	0.63 0.63	0.83	Pink, translucent
2	Burma	0.207 0.212	0.303 0.310	0.36 0.36	0.52 0.52	0.84	Light red, transparent
3	Mica P. O., Transvaal	0.128 0.123 0.117	0.187 0.180 0.172	0.48 0.51	0.68 0.73	0.89	Pink, opaque
4	Zoutpansberg, Transvaal	0.130 0.131	0.190 0.191	0.86 0.82 0.83	1.23 1.17 1.19	1.39	Light red, opaque
5	Franklin, Macon County, N. C.	0.283 0.287 0.294	0.414 0.419 0.429	1.17 1.20	1.67 1.72	2.11	Deep red, transparent
6	Siam	0.327 0.329	0.478 0.480	1.16 1.16	1.66 1.66	2.14	Dark red, transparent
7	Mysore, India	0.162 0.156	0.237 0.228	1.76 1.76	2.52 2.52	2.75	Deep red, translucent
8	Vatomandry, Madagascar	0.204 0.196 0.204	0.298 0.286 0.298	2.19 2.25	3.14 3.22	3.46	Red, opaque

The excess cupferron was destroyed with nitric and sulfuric acids, and the chromium was determined by the procedure already described;[6] the method was then applied to a number of naturally occurring rubies. The results of these determinations are recorded in Table II. It is worthy of notice that ruby No. 1 was associated with fuchsite, and that ruby No. 8 occurred in diaspore with biotite.

A glance at Table II shows that there is no regularity in the ratios of Cr_2O_3 to Fe_2O_3; on the other hand, the depth of color in the ruby seems to be proportional to the total amount of coloring oxide present, listed in the last column of Table II, rather than to the chromic oxide alone. The values in the last column were obtained by adding the average percentage of Fe_2O_3 and Cr_2O_3 in each specimen, and are in remarkable agreement with what has already been stated regarding the amount of pigmenting oxide necessary to produce the typical color in synthetic ruby.

Work is now in progress in this laboratory on the synthesis of ruby, using ferric oxide alone as coloring agent.

SUMMARY

A number of specimens of naturally occurring ruby have been analyzed for both their iron and chromium content.

The total amount of coloring oxide in these rubies has been found to vary between 0.83 and 3.5 per cent.

The depth of color of the rubies analyzed seems to be directly proportional to the total amount of pigmenting oxide present, irrespective of the amount of chromic oxide found.

There is apparently no fixed ratio of iron to chromium in the rubies analyzed.

The total amount of pigmenting oxide found in the more deeply colored natural rubies coincides with the amount that must be incorporated into synthetic preparations in order to duplicate the color of the natural gem.

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THE MOLECULAR WEIGHT OF THYROGLOBULIN[1]

THE preparation of highly purified thyroglobulin[2] has made possible determinations of the molecular weight of this protein in the ultra-centrifuge.[3] Throughout the pH stability range from 4.8 to 11.3 the sedimentation constant, s, has been found to average 19.2×10^{-13} in the case of thyroglobulin prepared from hogs grown in the United States as well as in Sweden. The preparations were quite homogeneous and there was little non-centrifugable material. A sample of human thyroglobulin showed essentially the same sedimentation constant, although the preparation was not quite so homogeneous. At pH 3 on the acid side of the iso-electric point (which has been found to be at about pH 4.5 by Dr. Kai O. Pedersen[4]) hog thyroglobulin is incompletely split into two components, of which the lighter shows an s of about 11×10^{-13}. On the alkaline side of the stability range, at pH 12, there is also splitting into components of lower molecular weight. A sedimentation equilibrium run has indicated a molecular weight of about 700 000. From the sedimentation constant of 19.2×10^{-13} and the diffusion constant found according to the method of Tiselius[5] by Mr. A. G. Polson to be about 2.0×10^{-7} a molecular weight of about 800 000 is indicated. The partial specific volume has been found to be 0.72, an unusually low value for a protein. Additional data and a detailed discussion will be given in a later paper.

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