

follows directly from the Maxwell theory of reflection and absorption. Experimental determinations of the total emissivity of platinum have verified the derived relation.

MINERALOGY.—*Four new minerals.* WALDEMAR T. SCHALLER, Geological Survey.

The following very brief notes of four new minerals are given in order to secure priority, as it is desired to extend further the optical determinations before the detailed papers are published. The formulas given have all been derived from the completed chemical analyses.

*Minasragrite* is a blue hydrous vanadium sulphate from Minasragra, Peru. The monoclinic crystals dissolve readily in cold water. The vanadium is quadrivalent and the mineral is a hydrous acid vanadyl sulphate with the formula  $V_2O_4 \cdot 3SO_3 \cdot 16H_2O$ , which is interpreted as  $(V_2O_2)H_2(SO_4)_3 \cdot 15H_2O$ .

*Fernandinite* is a green hydrous calcium vanadyl vanadate from Minasragra, Peru. The analysis yields the formula  $CaO \cdot V_2O_4 \cdot 5V_2O_5 \cdot 14H_2O$ , which may be written, as a metavanadate as follows:  $[H_4Ca(V_2O_2)][VO_3]_{10} \cdot 12H_2O$ .

*Shattuckite* is a blue hydrous copper silicate from the Shattuck Arizona Copper Company's mine at Bisbee, Arizona. Its formula is  $2CuO \cdot 2SiO_2 \cdot H_2O$  and it is close to plancheite in composition but differs considerably therefrom in its optical properties. Shattuckite forms pseudomorphs after malachite and also occurs as small spherulites.

*Bisbeeite* is found with the shattuckite and forms pseudomorphs after the shattuckite pseudomorphs of malachite. In composition bisbeeite is identical with diopside,  $CuO \cdot SiO_2 \cdot H_2O$ , but is orthorhombic, pale blue to nearly white in color, and has distinct optical properties.

ZOOLOGY.—*The geographical divisions of the recent crinoid fauna.* AUSTIN H. CLARK, National Museum.

The division of the present crinoid fauna as a whole into satisfactory zoögeographic regions has proved to be a task of no little difficulty, chiefly because of the almost complete absence

of these animals from littoral waters having a seasonal fluctuation of temperature and salinity, and because of the complete inter-gradation of the littoral and the abyssal types.

Yet the very features which place the greatest obstacles in the way of outlining the zoögeographic divisions indicated by the crinoids at the same time suggest that these divisions are of more than usual significance, and are more fundamental in character, especially in their relation to the zoögeographic divisions of the past, than those of the other groups of marine organisms.

In the construction of the scheme outlined below, instead of following the usual method of subordinating the biological to the geographical aspect of the problem, I have examined all the known species of recent crinoids from the point of view of their systematic affinities and their obvious relationships, later assigning them to the various zoögeographic divisions in which they appear naturally to group themselves, so that these divisions are outlined purely from the biological viewpoint, and follow, if it may be so expressed, the phylogenetic rather than the geographical migrations of the class.

The crinoid fauna of the present seas is found to be divisible into two main sections, which, though faunally equivalent, are different in size and range. These two zoögeographic units are:

I. THE AUSTRALIAN FAUNA: Occuring all around the coasts of Australia, and including the Aru Islands and southern New Guinea (Papua).

The Australian fauna, which is littoral and sublittoral only, is characterized by certain very distinctive, primitive and aberrant specific types. Three genera, *Comatulella*, *Oligometrides* and *Ptilometra* are confined to it, while *Zygometra* and *Petasometra* are here very highly developed. It is related to the Indo-Pacific-Atlantic fauna, though it cannot be considered as a part of it, or as a derivative from it. Of the several divisions of the Indo-Pacific-Atlantic fauna it is most closely allied with the Caribbean, and two of the three peculiar genera are, outside of the Australian region, most closely related to Caribbean types, *Comatulella* to the genus *Comactinia*, and *Oligometrides* to the genus *Analcidometra*; it is interesting to note that neither *Comactinia* nor *Analcidometra* occur on the eastern shores of the Atlan-

tic. The Australian and the Indo-Pacific-Atlantic faunas overlap more or less in the Moluccas and in the Lesser Sunda Islands, and at the present time the entity of the former has become clouded and largely masked through the intrusion of numerous alien types from the Malayan region, particularly on the east Australian coast. The Australian fauna appears to be the last remnant of a once dominant fauna which, overwhelmed by a more vigorous fauna of subsequent origin, now persists only in the Australian littoral, and, almost entirely submerged, in the littoral and sublittoral zones of the Caribbean Sea.

II. THE INDO-PACIFIC-ATLANTIC FAUNA: Primarily characteristic of the region from Formosa to the Korean Straits, and eastward to Tokyo Bay, the Hawaiian Islands, the Kermadec Islands, the Admiralty Islands, the Meangis Islands, the Moluccas, the Lesser Sunda Islands, thence westward and northward along the southern shores of Java and Sumatra to the Nicobar and Andaman Islands, Ceylon and southwestward to Madagascar and southeastern Africa, northwestern Africa and southwestern Europe, and the Caribbean Sea. From this primary region, which falls into numerous subdivisions, faunal units, more or less differentiated from the original unit, have been and are being evolved (the "derived" faunas mentioned beyond) which occupy the entire area of the present seas at all depths, excepting only the Australian littoral.

The Indo-Pacific-Atlantic fauna, chiefly developed between the temperature of  $10^{\circ}$  and  $18^{\circ}.33\text{C}$ . ( $50^{\circ}$  and  $65^{\circ}$  Fahrenheit), and composed entirely of species of moderate size, none very large and none very small, appears to represent the dominant, conservative, and homogeneous widely spread fauna of the more recent geological past, and to be the original homogeneous unit from which the recent faunal units are being evolved (1) by disruption of the ancient land continuity and consequent geographical differentiation, (2) by migration of certain virile types into the cold abysses where, becoming modified, they undergo redistribution as abyssal types, and (3) by migration of other virile types into the purely recent hot tropical littoral where, becoming modified, they are redistributed as a tropical littoral fauna.

The geographical divisions of the Indo-Pacific-Atlantic fauna are the following:

1. *Southern Japanese-Hawaiian*: Formosa to the Korean Straits, and eastward to Tokyo Bay; the Hawaiian Islands.

a. Southern Japanese: Formosa to southern Japan, from the Korean Straits to Tokyo Bay. b. Hawaiian: Hawaiian Islands.

2. *Kermadec Island*: Kermadec Islands.

3. *East Indian-Australian*: Andaman Islands southward and eastward to the Lesser Sunda Islands, the Moluccas, Celebes and the Meangis Islands, and southward (in deeper water than that in which the Australian fauna occurs) to southwestern Australia and Tasmania.

4. *Ceylon-East African*: Ceylon westward and southwestward to Madagascar and southeastern Africa.

5. *Atlantic*: Northwestern Africa and southwestern Europe, and the Caribbean Sea.

a. East Atlantic: Northwestern Africa and southwestern Europe. b. Caribbean: Caribbean Sea.

The derived faunas originating from the Indo-Pacific-Atlantic which include chiefly or entirely littoral and shallow water types are the following:

1. *Malayan*: The region westward and northward of the Andaman, Nicobar and Lesser Sunda Islands, and east of the Moluccas and Celebes, as far as the Philippine Islands and Hong Kong.

2. *Littoral Atlantic*: Norway to the Gulf of Guinea, including the Mediterranean Sea; Caribbean Sea to Rio de Janeiro, Brazil.

a. Afro-European: Norway to the Gulf of Guinea, including the Mediterranean Sea.

b. American: Caribbean Sea to Rio de Janeiro, Brazil.

3. *Red Sea*: Red Sea, and eastward to the Persian Gulf.

The derived faunas originating from the Indo-Pacific-Atlantic which include exclusively primarily deep water types are the following:

1. *Arctic*: Arctic Ocean and north Atlantic, south to Nova Scotia and the extreme north of Europe; the western shores of the Seas of Okhotsk and Japan.

- a. Arctic Ocean: Arctic Ocean, and the extreme north Atlantic.
- b. East Asiatic: Western shores of the Seas of Okhotsk and Japan.

2. *Antarctic*: Antarctic regions, and the west coast of South and North America to Alaska, westward to the western Aleutian Islands, and southward to southern Japan.

a. Continental Antarctic: Coasts of the Antarctic continent, Kerguelen, and Heard Island.

b. Megellanic: Cape Horn northward to Alaska, westward to the western Aleutian Islands, thence southward to Tokyo and Sagami Bays, Japan.

c. Abyssal: The abysses in the extreme south, and in the eastern and northern portions of the Pacific and Atlantic Oceans; probably also the abysses in the eastern part of the Indian Ocean.

The various geographical divisions of the Indo-Pacific-Atlantic fauna occupy each a relatively circumscribed area, supporting distinctive species; but the derived faunas, while characteristic of the area as delimited above, have ill-defined borders and encroach more or less upon the surrounding faunas.

Thus the Malayan fauna, especially characteristic of, and apparently originating in, the very warm water of the Malayan littoral, is very widely spread wherever very warm water occurs; a few of its distinctive species reach southwestern Japan, one reaches the Hawaiian Islands, and several reach Australia, where they overlie the species of the Australian fauna proper, especially on the northeastern and eastern coasts, reaching as far south as Perth and Sydney; Ceylon also supports a few representatives of this fauna. The Littoral Atlantic fauna, excepting in the Mediterranean Sea, overlies the true Atlantic fauna. The other derived faunas similarly have extended their ranges more or less into territory occupied originally by other faunal units.

The derived faunas appear to be the dominant faunas of the present seas, composed of the most vigorous and most adaptable elements in the original Indo-Pacific-Atlantic stock. This latter now appears to be on the road to complete submergence, owing to its inability to adapt itself as a whole to the increasingly diverse oceanographical conditions.