

HYDROCHEMICAL FACIES OF SURFACE GEOSPHERES

By G. A. MAXIMOVICH

(Communicated by W. I. Vernadsky, Member of the Academy, 29. I. 1943)

By a hydrochemical facies is meant the portion of aboveground and underground hydrosphere whose waters are throughout characterized by identical hydrochemical conditions as regards the predominance of certain dissolved substances (ions, colloids). The concentration and the chemical composition of the water in the particular portion are liable to certain variations, but the predominance of some definite substances is maintained.

A hydrochemical facies is determined by the first three (sometimes four or even more) components which exceed the other components in weight. The facies are given in the decreasing order of their significance. For different manifestations of the hydrosphere the following groups of hydrochemical facies or formations as defined by the predominance of a certain component have been established*.

Groups of hydrochemical facies or hydrochemical formations	Rivers	Lakes	Seas and oceans	Ground waters	Edge waters of the stratisphere
Silicious	+	+		+ ?	-
Hydrocarbonate	+	+	-	+	+
Calcium	+	-	-	+	-
Sulphate	+	+	-	+	+
Sodium	-	+	-	+	+
Chloride	+	+	+	+	+

Further investigation is likely to establish the silicious formation for the stratisphere also. The ground waters referring to this formation should, according to the analyses of fluvial waters, occur in the tropical zone and in the tundra.

Thus, with the exception of seas and oceans, the silicious, hydrocarbonate, sulphate and chloride hydrochemical formations are found in most of the water shells. The calcium hydrochemical formation, which is one of a poor stability, is known in the surface and underground streams. The sodium hydrochemical formation characterizes the rather immobile lake; ground and edge waters.

The bulk of sea and ocean waters, with the exception of small strips in the littoral waters, shows a concentration varying within fairly narrow limits; and these waters belong not merely to a single formation; but also to one facies (chloride- sodium-sulphate).

In general little variation is also shown by hydrochemical facies of rivers and lakes, or by ground and edge subterranean waters. This in spite of the fact that every such manifestation of the hydrosphere is distinguishable by some specific facies. Therefore it is the composition of the gases as indicated by W. I. Vernadsky (², ³), that should be considered as the main distinguishing feature of the hydrochemical facies of the different hydrospheres, their portions and manifestations.

The next problem is to characterize the gaseous composition of different hydrochemical facies, as well as of subsidiary mineral components in solution, and of the organic matter dissolved. In particular, oil-field waters are characterized by the presence of naphthenic acids (⁷). Enrichment with iodine and bromine (⁴, ⁶) is, along with helium-argon coefficient (⁹), a remarkable feature of pelogenic chloride-sodium-calcium waters of the stratisphere, destitute of sulphate.

The hydrochemical facies of rivers, lakes and ground waters displays zonal distribution. There are 5 main zones; the tropical zone, two steppe and desert zones, and two zones of moderate climate. Moreover, four subzones may be distinguished which; with increasing accumulation of hydrochemical data, are likely to rise to the rank of zones. These are two steppe subzones (one in the northern, the other in the southern hemisphere) and two zones of tundra. Apart from this, the rivers and lakes have also a vertical (mountainous) zone. Ground waters are scarcely developed in mountainous regions: they occur in the alluvium of river terraces, etc. and so they show no zonal distribution along the vertical.

Azonal phenomena may be caused by hydrological, geological and lithological peculiarities, and also by the activity of man.

Rivers and ground streams may several times change their facies along the direction of the flow. The majority of long rivers are polyfacial. Ground streams that cover a smaller range show a less facial change along their path. Lakes and ground basins change their hydrochemical facies not only in the horizontal, but also in the vertical direction. The gaseous composition of the lakes also varies along the vertical.

The hydrochemical facies of rivers, lakes and ground waters vary not merely in space, but also according to the age.

As a typical complex of predominant soluble substances in river, lake and ground waters, the hydrochemical facies indicates definite climatic conditions under which the concentration and formation of the composition of these waters went on, as well as soil, geochemical (weathering), hydrological and hydrogeological factors which are all correlated with the climate. A change of climatic conditions results in a change of hydrochemical facies and in the shifting of their zonal boundaries.

In the case of edge waters of the stratisphere the hydrochemical facies change with the distance from the outcrop of the stratum to the surface; which goes parallel with the increase in concentration. The activity of microorganisms is another important factor in the transformation of edge waters. The edge waters of the stratisphere, unlike fluvial, lake and ground waters, can be of syngenetic, as well as of epigenetic nature. The former are distinguishable by a peculiar

* It will be hardly correct not to take in account at water classification the organic substances sharply different in the tropic and the arctic belts.

hydrochemical aspect.

The hydrochemical facies vary not only along the strata, but in a series of strata they also vary along the vertical.

The character of hydrochemical facies of edge waters of the stratisphere is determined by the origin of the waters, by their concentration, by the composition of the reservoir and its inclosing rocks, and is also dependent on permeability, on the presence or absence of tectonic fissures and erosion phenomena that cause the denudation of the stratum, on the accumulation of organic matter, on the activity of organisms, on geotectonic and geomorphological conditions and, finally, is variable with the time elapsed since the waters were formed in the stratum (age).

The first in importance are the geotectonic and geomorphological conditions and also the permeability. Flat areas with a slightly dissected relief are characterized by gases of biochemical and partly of atmospheric origin (¹). They also contain strongly concentrated waters of chloride type (¹⁰). In the majority of cases, concentration grows with depth.

Geoanticlinal regions represented by modern mountainous folded structures are characterized by the presence of metamorphic gases in their centre. Away from the centre to the periphery the origin of the gases varies in the order: mixed metamorphic and atmospheric; atmospheric; atmospheric mixed with biochemical; biochemical. Generally speaking, the hydrochemical facies vary in the same direction, and the hydrocarbonate type is superceded by the sulphate, sodium and chloride type. However, denudation differences in the case of fissures and erosion, as well as the different perviousness account in many cases for the absence of a regular change of concentration or of hydrochemical facies along the vertical. This along with different composition of the rock gives rise to peculiar azonal phenomena which stand out in the otherwise zonal succession of hydrochemical facies depending upon the structure – from the centre of the mountainous folded region towards the platform.

Hydrochemical facies of edge waters of the stratisphere vary not only in space, but also with time. Changes in the rate of migration, feeding conditions bring about changes in the concentration and sequence of hydrochemical facies. The activity of man plays an important and gradually increasing part in the varying rate of migration of edge waters.

Among the facies of the surface hydrospheres; the hydrochemical facies of fluvial, lacustrine, ground and edge waters are the most labile. Thus, we are to add to the facies of the crust of weathering and the stratisphere (⁸), to the facies of the pedosphere (and various types of soils should practically be considered as such), to the facies of sedimentary, eruptive and metamorphic rocks [as well as to the biochemical provinces determined by A. P. Vinogradov(⁵)] also the highly mobile and variable hydrochemical facies.

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