Some Aspects Relating to the Sodic Salinization of Soils in the Subhumid Regions of Europe and Asia

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There still remain many obscure aspects relating to the origin of the sodic salinization of soils. For instance, it is not an easy task to decide what is responsible for soda formation in a particular case.

The reasons for sodic salinization expansion to the north of the main area of salt accumulation in soils are still lacking clarity.

The possibility of soda formation from other sodium salts in a biochemical way aggravates the solution of these problems. Though strict experimental results proving the biological formation of soda under soil conditions do not exist, many researchers consider these particular reactions to be universal in attempting to explain the origin of almost all known cases of sodic salinization. Such a broad approach to the interpretation of these reactions is hardly justified and is at variance with well-established facts. Researchers should be careful, because any erroneous solution of the problems relating to salinization processes is fraught with serious consequences.

It is quite evident that both the elimination and prevention of sodic salinization of soils can vary depending on whether the soda has been formed in the soils — close to the earth's surface or brought by the soda-containing solutions ascending with the subterranean waters from the entrails of the earth where it can be formed in different ways.

In a number of cases, the reliable geological and hydrochemical data, obtained from depth, may serve as a basis for solving the aforementioned problems but soil scientists do not always use such data.

Certain indirect data can be made use of in a preliminary attempt to elucidate the origin of soda.

One of the possible approaches in determining the ways of soda migration is to consider the geochemical peculiarities in the behaviour of other soluble salts accompanying soda, as their appearance is intimately related to the conditions of soda formation. It is also just to assume that the soda formation peculiarities should be somehow reflected in the final stages of the process, i.e. in soil salinization.

Some years ago, the author of this paper had an opportunity to analyze the process of sodic salinization of soils on the alluvial fans in the foothills of the Kunlun mountains (EGOROV [2]). It is possible to consider these data as standard ones in studying the conditions of soda formation resulting from the processes of the desertic weathering of massive-crystalline rocks.

Soda in the ground waters and soils of the considered case is accumulated

in smaller amounts than sulphate and chlorine-ions, the sulphate ion being prevalent in the soils. The content of the latter in the ground waters approximates that of chlorine while each of them exceeds the HCO_3 ion content.

A close similarity to the above described salinity of ground waters and soils occurs in the Arazdayan steppe of the Armenian SSR, which, according to its tectonics and geomorphology, has nothing in common with an alluvial fan. However, the conditions for ground water replenishment and the formation of its hydrochemical composition are almost identical with those in the foothill zone of the Kunlun. Analogous cases are known to have been encountered in the North Caucasus.

If one undertakes a comparison between the mentioned salt association and that in the soda-salinized areas on the Euro-Asiatic Plain, one might easily notice certain conspicuous differences between the two variants.

Close to the western border of the USSR, in Moldavia's central region, there lies an area of sodic salinization. This type of salinity manifests itself rather often in spite of the considerable ruggedness of relief and adequate drainage of the territory. It occurs in the river valleys, on the slopes exposed to them, and even in areas with flat topography.

According to geological investigations, the source of soda-containing hydrocarbonate waters is known to occur in the entrails of Tertiary organogenous limestones whose confining bed is dissected in some places by deep river valleys. Waters in the upper layers of the limestone formations have been subjected to a partial and in the deeper ones to a complete desulphurization (Vzmuzdaov [8], Nikitina [6]). The ground waters proper contain a certain amount of soda, but their salt composition is mainly represented by sulphates and to a very small extent by chlorides. The sodic salinization actively manifests itself in those places where weakly confined waters outpour, often forming small gryphens (local name "okers").

Thus, there is every basis for speaking about an abysmal origin of the sodic salinization of soils in Moldavia. Unfortunately, a number of authors admit the possibility of soda formation here as a result of sulphate reduction as well as according to the Hilgard reaction which makes it impossible to ascertain the main source of soda. It should be noted that just the same situation is characteristic of a number of structures in the North Caucasus where soda-containing waters occurring in limestones are always rich in hydrogen sulphide.

A more eastern area of sodic salinization on the East-European Plain lies in the Dnieper depression superficially filled with ancient alluvial postglacial deposits. Under the arid conditions such surfaces are characterized by the sulphate and chloride types of salinization, the former predominating.

N. G. Sambur, an expert on this region, wrote [7] that sodic salinization is an initial one in the northern (forest-steppe) areas, whereas sodium sulphates and partly chlorides contribute to the salinization of soils only in the southern parts of the Middle Dnieper Region.

The artesian or subartesian waters, whose recharge area is situated in the North, are known from the geological literature to discharge into the Dnieper depression.

Prior to connecting the origin of soda in this particular region with this or that hypothesis, let us consider one more soda-salinized area on the Russian Plain. The Voronezh—Tambov Lowland is also confined to a platform

depression with a relatively shallow basement bowing. Soil salinization occurring in this lowland is distinguished by the predominance of soda. A subordinated accumulation of sulphates and an insignificant accumulation of Cl salts are possible in the ground waters occurring under the solonchaks. Like in the Dnieper depression, salinization here is progressing under the influence of the ground water recharge which makes it possible to suggest an abysmal source of soda.

The platform depressions were formed rather slowly. They are characterized by a shallow bowing and limited (contrary to the foredeeps) sources of organic matter accumulation. The detrital material of glacial origin, which accumulated in such depressions during the Quaternary period, was lacking organic residues. Proceeding from all these considerations, it can be suggested that the origin of the sodic (hydrocarbonate) waters in the conditions of these particular regions, is closely related to the processes of mineral breakdown and extraction of sodium silicate which forms soda when encountering hydrocarbonate ions (KOVDA [4]). An inconstant, usually low content of chlorine and sometimes of sulphates in such waters is quite natural as it reflects both the long-term washing out of more mobile compounds from the rocks with a simultaneous draining of the surface series of rocks by the river network and the composition of rocks poor in such compounds.

To the east of the Urals there is a vast area of soda salinized soils of the Baraba Lowland. According to BAZILEVICH [1], in the Tertiary and Quaternary periods this lowland served as an area of accumulation of salts transported with the surface runoff. Accumulation of sulphates generally predominates under such conditions. The appearance of soda here has been attributed by a number of researchers to the biochemical reduction of sulphates in the soil.

Indeed, the salt composition in the places of progressing salinization, caused by shallow ground waters, is characterized (but not everywhere) by an exclusive predominance of chlorides over sulphates especially in the ground waters. However, attempts to prove the reduction of sulphates in the soil have been unsuccessful (KOSLOVSKY [5]).

The composition of the river as well as lake waters, as an integral index of those components which prevail in the most actively outpouring ground waters into the valleys and depressions, is also distinguished by a large amount (next to the hydrocarbonate content) of chlorides.

Thus, if there is no reliable evidence of the process going on close to the earth's surface, the local ground waters of the Baraba Lowland can be considered to be desulphurized. Moreover, we can already dispose of the data on the discharge of the allochthonous internal waters in the Baraba Lowland (GARMONOV et al [3]). This type of chemism and the presented geological data make it possible to speak, first of all, about the inflow of the desulphurized chloridic-sodic waters from depth. In some places close to the earth's surface these waters mix with the richer sulphate solutions accumulating the products of the post-glacial period. The latter cannot be treated as the main source of soda.

It is remarkable that the tectonic region of the Baraba Lowland as a part of the West-Siberian Plain differs from the depressions of the East-European platform.

The West-Siberian Lowland is an area of a deep bowing of the basement. Surface and marine deposits of great thickness, which include noticeable

amounts of organic substances, were buried in its entrails. The development of the desulphurization process accompanied by the discharge of the reduced (with respect to sulphates) waters into the upper layers of rocks and the river network is quite probable.

Familiarization with the saline soils on the Nonnii-Sungari alluvial plain in Manchhuria has enabled the author to arrive at a conclusion on the abysmal source of soda in that region. The Nonnii-Sungari Lowland is also an area of deep bowing of the basement composed of continental-marine deposits overlain by the newest alluvium. The slightly saline, hydrocarbonate-chloride sodium ground and subsoil waters, spread everywhere in the central part of this lowland, insure weak and moderate sodic salinization of soils with the participation of chlorides.

The alluvial fans of the local river streams which do not reach the Sungari (the main river) are exposed to the centre of the Plain. These alluvial fans occurring on the surrounding elevated terraces of early Quaternary and Tertiary ages are characterized by their geochemical zonality and forms of a more pronounced salinization which is predominantely of sulphate or soda-sulphate types. The hydrocarbonate-alkaline salinization, according to the analyses of core samples collected in the geological borings, has been traced down to a depth of several hundred metres.

The investigations have resulted in revealing a powerful, undoubtedly abysmal source of the soda-containing solutions ascending to the earth's surface as subartesian hydrocarbonate sodium, slightly chloridic desulphatized sub-terrainean waters.

This type of abysmal salinization is somewhat complicated on the edges of the lowland by the continental sulphate-containing solutions.

Based on the presented data we can return and consider one of the omitted areas of sodic salinization situated in the Samara river (tributary of the Volga) basin in Zavolzhye (a region adjoining the Volga river). Sodic salinization of soils, manifesting here in the river valleys, should be attributed to the ascension, from the entrails of the Earth, of abysmal soda-containing solutions.

Elucidation of the reasons for the sodic salinization of soils in Yakutia, an area of permafrost, is the most complicated task. As in most of the cases, the sodic salinization here occurs on the alluvial plain (in the middle stretches of the Lena river).

Many mysterious things with regard to the sodic salinization in Yakutia may be cast aside if one shares the viewpoint on the occurrence of salinization here by the effect of the abysmal hydrocarbonate solutions prior to the formation of permafrost. With the onset of Glaciation it could have been preserved.

Thus, the available direct and indirect data, without denying the existing hypotheses on soda formation, make us prone to admit the predominantly abysmal source of this compound.

The above presented considerations reflect a very schematized attempt to approach the understanding of the origin of sodic salinization in the subhumid alluvial plains of Europe and Asia.

It is also self-evident that investigations on the reasons of sodic salinity occurrence should not solely concentrate on the solution of chemical problems. A researcher should take into account the whole complex of natural factors.

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