Influence of the gley process on the mineral composition of soils
Influence des processus de gleyification sur la composition minéralogique des sols

LESOVAYA S.

Soil Department, Biology soil faculty, University of St Petersburg, Universitets Raja no 7-9, 199034 Saint Petersbourg, Russie

Summary
For the first time the term “gley” was propounded in scientific literature by Russian soil scientist G.N. Vysotcki (1905).

The subject of gley formation includes the development of the reduction processes in the anaerobic conditions and low degree of Red-Ox potential. The reason of these conditions is prolonged season or constant wet environment.

In the results of gley process soil physical properties become worse; soil aggregated substance become more mobile; iron, manganese, sulphates reduce; ferromanganiferous concretions synthesis. Some changes take place in the mineral part of soil. Particularities of gley formation appear on both micro and macro degrees.

Gley formation is one of the spreadest and absolutely essential processes in the humid region. This process is concerned with the soils developed on all well-known types of parent rocks which have got different genesis, chemical and mineral compositions.

The mineralogical and chemical compositions of soils and parent rocks affect on their stability against gley process. Thus the estimation of soil stability against gley process is absolutely essential for practice.

In regard to the attempt to estimate the soils and parent rocks stability against gley formation was taken place by G. Niroomand, J. Tedrow (1990). The results of model experience was shown that red shale contained hematite was responsible for stability against gley.

F.R. Zaidelman with co-authors (1978) researched the changes of chemical and mineralogical compositions of three types of parent rocks which took place during the gley formation. These researches took place on the example of model experiment.

It was shown that during the gley formation mixed-layered mica-smectite mineral was destroyed or clay fraction lost smectite packages especially in acid environment. The results of their researches was the opinion that during the gley formation the protective layers of iron hydroxides were
dissolved. These iron hydroxide layers were situated on the surface of clay particles.

Problem

On the North-West of Russian Plain in the conditions of wide spreadest Podzol soils there are soils which morphological, chemical and mineralogical properties are different from Podzol soils. The reason of this is the location of Pre-Quaternary rocks close to the day surface. In these conditions local moraines are formed.

Local yellow grey carbonate moraine was formed in the conditions of the location of Pre-Quaternary carbonate rocks (O2) close to the day surface. Local red carbonate or noncarbonate moraines were formed in the conditions of the location of Pre-Quaternary red rocks (D2,3) close to the day surface. In both conditions soils with poor differentiation on the horizons are formed.

The fertility soils (especially on the yellow-grey one) is higher than Podzol soils of North-West of Russia. Soils on the local moraines haven't own podzol horizon as Podzol soils have and the Podzol process isn't the aim process of these soils. The reason of this is admixture Pre-Quaternary substance to the parent Quaternary rocks.

It's logically to suppose that the influence of the gley formation on the mineral composition of these soils different from Podzols soils.

For example N.Matenyan (1968) investigated that mixed-layered mica-vermiculite-smectite mineral are formed during the gley process in Podzol soils of North-West of Russia Plain.

Since the reason of peculiarity of soils on the local moraines is admixture of Pre-Quaternary substance the main purpose of our researches was to investigate the changes of mineralogical composition during the gley formation on 3 types of parent rocks in the conditions of model experiment.

The objects of our investigations were:
1) sample from C horizon of the soil on the red noncarbonate sand local moraine. The Pre-Quaternary rock is D2br;
2) sample from C horizon of the soil on the red noncarbonate clay local moraine. The Pre-Quaternary rock is D2br;
3) sample from C horizon of the soil on the yellow-grey carbonate moraine. The Pre-Quaternary rock is O2kg.

These samples were flooded with 1% solution of glucose and stayed on 6 months. Greyish-colour spots appeared in all samples in 1 month. The same samples were flooded with distilled water for the control. There weren't changes of their colour until the end of the experiment.

The analyses of mineralogical compositions of finely dispersed fractions (clay < 0.001 mm. and fine silt 0.001-0.005 mm.) were laid in the basis of our investigated. Separation of fractions were performed by the Gorbunov’s method (N.E. Gorbunov, 1977).

The content of clay minerals in these fractions were calculated by the Biscaye method (Biscaye, 1965) using data of X-RAY studies.
Results and their discussion.

Sample N 1

The clay fraction has hydromica composition (66%) including both trioctahedral and dioctahedral hydromica. There are kaolinite and chlorite (32%) (kaolinite is predominated by chlorite). The content of smectite packages is 2%. Mixed-layered phase contains chlorite-smectite, chlorite-vermiculite (chlorite and vermiculite packages predominated).

There are hydrobiotite, finely dispersed quartz, goethite (\(\alpha\)FeOOH), hematite (\(\alpha\)Fe2O3) (the content of hematite is 0.5%, using the data obtained by Mossbauer Spectroscopy method, and lepidocrocite (\(\gamma\)FeOOH) in small quantity).

The mineralogical composition of fine silt fraction is different from one of clay fraction:
1) there isn’t own smectite in it;
2) hydromica is predominated by sum of chlorite and kaolinite;
3) chlorite is predominated by kaolinite;
4) the quantity of mixed layered fraction is smaller, it is most likely hydromica in this fraction has more Fe in octahedral position (the relation J1.0/ 0/ 5 is some higher in this fraction).

By the end of this our experiment the pH of solution has been changed from 5.4 to 4.1, the quantity of iron in it is 0.1% , it is approximately 5% of whole Fe and ~ 14% of nonsilicate Fe (extractable by Mehra and Jackson method).

The relation of both clay mineral composition and J1.0/ 0.5 was not changed, the last means that Fe has not got lost from octahedral position of hydromica.

But the quantity of mixed-layered fraction became higher in clay fraction. We has come to the opinion that the reason of this is the transformation mica to mixed-layered mica-vermiculite mineral.

Mixed-layered fraction has just displaced to 1.4 nm. reflex in the fine silt fraction.

Sample N 2

The mineralogical composition of this sample different from the previous one:
1. there isn’t smectite in it;
2. the quantity of hydromica is higher. The relation J1.0/ 0.5 is same both in clay and fine silt fractions. It means that the quantity of Fe in octahedral position of gydromica is similar;
3. the mixed-layered fraction is composed from mica-smectite (vermiculite), mica-chlorite; in this fraction mica and chlorite packages predominate.

The quantity of this phase in fine silt fraction is lower than in clay. In this fraction the sum of chlorite and kaolinite predominate hydromica but we cannot say about the predomination of chlorite or kaolinite.

There are quartz, goethite, hematite (the content of hematite is 2.3% using the data obtained by Mossbauer Spectroscopy method).

By the end of this our experiment the pH of solution has been changed from 6.0 to 4.4, the quantity of iron in it is 0.3%, it is approximately 5% of
whole Fe and \( \sim 10\% \) of nonsilicate Fe (extractable by Mehra and Jackson method). The last is slightly lower than in previous sample.

The relation of \( J_{1.0}/0.5 \) becomes slightly lower (from 2.3 to 1.8), it is most likely that hydromica has lost some Fe from octahedral positions (e.g. in the experiment which was performed by Zaidelman with co-authors, 1978) the relation of \( J_{1.0}/0.5 \) decreased 1.5-2 times).

In the clay fraction the quantity of mixed-layered minerals has become higher. The quantity of hydromica has become lower especially in comparison with mixed-layered phase. We have come to the conclusion that the reason of this is the transformation of hydromica to the mixed-layered mineral (hydromica-vermiculite).

As in the sample N 1 mixed-layered fraction only has displaced to 1.4 nm. reflex in the fine silt fraction.

**Sample N 3**

The only fraction which was investigated in this sample is clay one. The dioctahedral hydromica with high level of Fe predominates in this sample. Mixed-layered mineral is mica-smectite (vermiculite), mica package predominates here.

Be the end of this our experiment the pH of solution has been changed from 8.8 to 5.3, the quantity of iron in it is 0.15\%, it is approximately 4\% of whole Fe and \( \sim 11\% \) of nonsilicate Fe (extractable by Mehra and Jackson method).

The transformation of the mineralogical composition of this sample has practically been not changed by the end of the experiment.

<table>
<thead>
<tr>
<th></th>
<th>( \text{Fe}^\text{t} )</th>
<th>( \text{Fe}^\text{d} )</th>
<th>( \text{Fe}^\text{t} \text{ in solution} )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>sample N1</strong></td>
<td>1.86</td>
<td>0.70</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>sample N2</strong></td>
<td>6.00</td>
<td>2.99</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>sample N3</strong></td>
<td>4.00</td>
<td>1.30</td>
<td>0.15</td>
</tr>
</tbody>
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**Conclusion**

1. Clay minerals in the researched samples with the high relative level of nonsilicate or carbonate has not lost intensively Fe from octahedral position.
2. The transformation of hydromica to mixed-layered mineral (mica-vermiculite) has taken nonsignificant place in all samples.
3. The same transformation of clay minerals within the course of gley formation takes place not only in the clay fraction but also in the fine silt fraction (such conclusion is based on our experience with samples of rocks with high level of iron).

Keywords : gley process, mineral composition, Russian plain
Mots clés : gleyification, composition minérale, plaine russe