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MATHEMATICS

M. Okropiridze

On the Symmetric Differentiability of Functions of Two Variables

Presented by Corr. Member of the Academy V.Kokilashvili, June 22, 1998

ABSTRACT. **We introduce the notions of symmetrically totally differentiability, symmetric partial derivatives in strong and in angular senses for functions of real variables. There is a relation between them.**

Key words: symmetric differentiability, symmetric partial derivatives in the strong sense, symmetric partial derivatives in the angular sense.

Bellow, we will assume everywhere that the function to be considered receives only finite values.

It is said that the function $f(x)$ at an inner point x_0 of the interval (a, b) possesses symmetric derivative, if the following limit exists

$$\lim_{h\to 0}\frac{f(x_0+h)-f(x_0-h)}{2h} \quad (*)$$

and sometimes it is denoted by symbol $f^{(1)}(x_0)$. This definition was introduced by P. Du Buis-Reymond in 1875 [1,2] and (*) – limit was used by M.V. Ostrogradsky [2,3].

Definition 1. A function $f(x, y)$ is said to possess, at a point (x_0, y_0), symmetric partial derivative with respect to x [with respect to y], if there exists limit

$$\lim_{h\to 0}\frac{f(x_0+h, y_0)-f(x_0-h, y_0)}{2h} \equiv f_x^{(1)}(x_0, y_0)$$

[correspondingly

$$\lim_{k\to 0}\frac{f(x_0, y_0+k)-f(x_0, y_0-k)}{2k} \equiv f_y^{(1)}(x_0, y_0)\,]$$

Definition 2. A function $f(x, y)$ will be called symmetrically totally differentiable or simply, symmetrically differentiable at the point (x_0, y_0) if there exist two finite numbers $A = A(x_0, y_0)$ and $B = B(x_0, y_0)$ such that

$$\lim_{(h,k)\to(0,0)}\left[f(x_0+h, y_0+k)-f(x_0-h, y_0-k)-2hA-2kB\right]/\left[|h|+|k|\right]=0.$$

Theorem 1. *If the function $f(x, y)$ is symmetrically differentiable at the point (x_0, y_0), then there exist $f_x^{(1)}(x_0, y_0)$ and $f_y^{(1)}(x_0, y_0)$. Not vice versa.*

Remark1. Analogue of the Theorem1 has no place with approximately differentiability [4].

Theorem 2. *If the function $f(x, y)$ is differentiable in the sense of Stolz at the point (x_0, y_0), then $f(x, y)$ is symmetrically differentiable at (x_0, y_0). Not vice versa.*

Definition 3. A function $f(x, y)$ is said to possess, at a point (x_0, y_0) symmetric strong partial derivative with respect to x [with respect to y], if there exists limit

$$\lim_{(h,k)\to(0,0)} \frac{f(x_0+h, y_0+k)-f(x_0-h, y_0+k)}{2h} \equiv f_{[1]}^{(l)}(x_0, y_0)$$

[correspondingly

$$\lim_{(h,k)\to(0,0)} \frac{f(x_0+h, y_0+k)-f(x_0+h, y_0-k)}{2k} \equiv f_{[2]}^{(l)}(x_0, y_0)\ ]$$

Theorem 3. *If there exist* $f_{[1]}^{(l)}(x_0, y_0)$ *and* $f_{[2]}^{(l)}(x_0, y_0)$, *then the function* $f(x, y)$ *is symmetrically differentiable at the point* (x_0, y_0). *Not vice versa.*

Theorem 4. *Differentiability of the function* $f(x, y)$ *in the sense of Stolz at the given point and existence of strong symmetric partial derivatives at the same point are non-comparable properties.*

Definition 4. A function $f(x, y)$ is said to possess, at a point (x_0, y_0) symmetric angular partial derivative with respect to x [with respect to y], if for every constant $c > 0$ there exists c-independent limit

$$\lim_{\substack{(h,k)\to(0,0)\\ |k|\le c|h|}} \frac{f(x_0+h, y_0+k)-f(x_0-h, y_0+k)}{2h} \equiv f_1^{(l)}(x_0, y_0)$$

[correspondingly

$$\lim_{\substack{(h,k)\to(0,0)\\ |h|\le c|k|}} \frac{f(x_0+h, y_0+k)-f(x_0+h, y_0-k)}{2k} \equiv f_2^{(l)}(x_0, y_0)\ ]$$

Theorem 5. *Symmetric differentiability and existence of symmetric angular partial derivatives of function* $f(x, y)$ *are non-comparable properties.*

Remark 2.It is known, that differentiability in the sense of Stolz is equivalent to the finiteness of angular partial derivatives [5].

Theorem 6. *If the function* $f(x, y)$ *is symmetrically differentiable at the point* (x_0, y_0) *and there exist finite* $f_{[1]}^{(l)}(x_0, y_0)$ [*or* $f_{[2]}^{(l)}(x_0, y_0)$], *then there exists finite* $f_2^{(l)}(x_0, y_0)$ [*correspondingly* $f_1^{(l)}(x_0, y_0)$].

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REFERENCES

1. *P. Du Buis-Reymond*. Z. Math. und Phys., His-lit. Abt., 1875, 20, 121-129.
2. *F.A. Medvedev*. Razvitie ponyatiya integrala. Moscow, 1974, 216 (Russian).
3. *M.V. Ostrogradsky*. Polnoe sobranie trudov. vol.3, Kiev, 1961, 166 (Russian).
4 *S.Saks*. Theory of the integral. Monografic Mathematychne. VII, Warszawa-Lvow, 1937, 300.
5. *O.P. Dzagnidze*. Proc. A. Razmadze, Math. Inst, 106, 1993, 7-48.

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MATHEMATICS

S. Kemkhadze

Geometries which are Connected with General Geometric Lattices

Presented by Corr. Member of the Academy H.Inassaridze, December 2, 1997

ABSTRACT. **This paper is an attempt to give an axiomatic description of those geometries which are bound with *D*-geometric lattices.**

Key words: lattice, D-geometric lattice, D-point, D-semimodular.

Consider the pair $\langle A, \bar{} \rangle$ consisting of the non-empty set A and the mapping $X \to \bar{X}$, $X, \bar{X} \in P(A)$ which satisfies the following conditions:

(i). $X \subseteq \bar{X}$, $X \subseteq Y$ implies $\bar{X} \subseteq \bar{Y}$; $\bar{\bar{X}} = \bar{X}$

(ii). $\bar{\varnothing} = \varnothing$; $\overline{\{x\}} = \{x\}$ for every $x \in A$.

The partial ordered relation on A is defined as follows:

for every $x, y \in A$ we'll consider that $x \leq y$ if and only if there exists an element $U \in P(A)$ such that $\overline{x \cup U} \subseteq \overline{y \cup U}$.

It's evident that for every $x \in A$ the subset A consisting of all elements less than x is a lattice.

Definition 1. General geometry is a pair of $\langle A, \bar{} \rangle$ consisting of nonempty set A and mapping $X \to \bar{X}$, $X, \bar{X} \in P(A)$ which satisfies the following five conditions:

(i). $X \subseteq \bar{X}$, $X \subseteq Y$ implies $\bar{X} \subseteq \bar{Y}$; $\bar{\bar{X}} = \bar{X}$

(ii). $\bar{\varnothing} = \varnothing$; $\overline{\{x\}} = \{x\}$ for every $x \in A$.

(iii). If $x \in \overline{X \cup \{y\}}$ but $x \notin \bar{X}$ then there exists an element $y_1 \in A$, $y_1 \leq y$ such that the interval $[y_1, y]$ is finite and $y_1 \in \overline{X \cup \{x\}}$.

(iv). If $x \in \bar{X}$ then there exists a finite subset $X_1 \subseteq X$ such that $x \in \bar{X}_1$.

(v). For every element x of L the set of all elements less than x is an infinite distributive lattice with maximum condition.

Lemma 2. [1]. *Let $\langle A, \bar{} \rangle$ be the closure space (i.e. $\langle A, \bar{} \rangle$ satisfies only 1(i)). Then the set $L\langle A, \bar{} \rangle = \{X \mid X \subseteq A\}$ is a complete lattice provided the relation of lattice inclusion is taken to be the set relation and $\wedge Y = \cap Y$ for every $Y \subseteq L\langle A, \bar{} \rangle$.*

Conversely, if the subset $L \subseteq P(A)$ is closed with respect to arbitrary intersections then the mapping $X \to \bar{X} = \cap (Y \mid Y \supseteq X, Y \in L)$ defines the closed space $\langle A, \bar{} \rangle$ and the closed sets of this space would be the elements of the set L and only they.

Hence, the closure space could be defined by the lattice L of closed sets.

Proposition 3. [1]. *A lattice L is algebraic if and only if L is isomorphic to the lattice of all closed sets of some algebraic lattice.*

The following theorem shows the relation between D-geometric lattices and general geometries.

Theorem 4. *Let $\langle A, \bar{} \rangle$ be general geometry, then the lattice $L = L\langle A, \bar{} \rangle$ is D-geometric. Conversely, let L be the D-geometric lattice and A the set of all D-points of*

the lattice L. For every subset $X \subseteq A$ *let X be the set of D-points tense by the set X. Then* $\langle A, \overline{\ } \rangle$ *is general geometry and* $L \cong L\langle A, \overline{\ } \rangle$.

Proof. Let $\langle A, \overline{\ } \rangle$ be general geometry. Then according to lemma 2 the lattice $L = L\langle A, \overline{\ } \rangle$ is algebraic lattice. The set X is compact if and only if $X = X_1$ for some finite subset $X_1 \subseteq X$. Hence, the compact elements of L are the finite units of D-points and only they. Now we need to show that the lattice L is D-semimodular.

Let $X, Y \in L$, $Y = \overline{X \cup \{x\}}$, but $x \notin X = X$. The proof of that fact, that $X \overset{D}{<} Y$ needs to show that:

α) The interval $[X, Y]$ is the infinite distributive lattice with maximum condition;

β) For every $Z \in L\langle A, \overline{\ } \rangle$ with $X \subset Z \subseteq Y$ one and only one from the following two intervals: $[X, Z]$ and $[Z, Y]$ is the torsion free lattice.

α) It follows from 1(ii) and 1(v) that $\{x\}$ is a D-point of the algebraic lattice $L\langle A, \overline{\ } \rangle$. Hence, the interval $[X, \overline{X \cup \{x\}}]$, $x \notin X$ is isomorpic to a D-point.

β) Let, $Z \in L$, $X \subset Z \subseteq Y$. Hence, there exists an element $z \in Z - X$, i.e. $z \in \overline{X \cup \{x\}}$ and $z \notin X$. Then by 1(iii) there exists an element $x_1 \leq x$ such that $[x_1, x]$ is the finite interval and $x_1 \in \overline{X \cup \{z\}} \subseteq Z$. Therefore, $x_1 \in Z \subseteq \overline{X \cup \{x\}}$ and this means that $[Z, Y]$ is a finite interval.

Now, let $U \in L$. Then $Y \vee U = \overline{Y \cup U} = \overline{X \cup U \cup \{x\}}$ and $X \vee U = \overline{X \cup U}$. Then $x \in \overline{X \cup U}$ and hence $X \vee U = Y \vee U$, or $x \notin X \cup U$ and $X \vee U \overset{D}{<} Y \vee U$. It proves that $L\langle A, \overline{\ } \rangle$ is D-semimodular lattice.

Let L be D-geometric lattice, A be the set of all D-points of L and X - the set of D-points, tightened by set X, $X \subseteq A$. It is evident that $\langle A, \overline{\ } \rangle$ is the closure space. The truth of the conditions 1(ii) and 1(iv) directly follows from the definition. Let's verify the validity of condition 1(iii).

Let $x \in \overline{X \cup \{y\}}$, $x \notin \overline{X}$. By the D-semimodularity of L we have $\overline{X \cup \{y\}} = \overline{X \cup \{y\}} > \overset{D}{} X$. Hence $X \subset \overline{X \cup \{x\}} \subseteq \overline{X \cup \{y\}}$ implies that $[\overline{X \cup \{x\}}, \overline{X \cup \{y\}}]$ is the finite interval. This implies the existence of such element $y_1 \leq y$ that $[y_1, y]$ is the finite interval and the inclusion $y_1 \in \overline{X \cup \{x\}}$ is true.

Now we'll prove that $L \cong L\langle A, \overline{\ } \rangle$. Consider the mapping φ: $X \to \vee X$, $X \subseteq A$, $X \in L\langle A, \overline{\ } \rangle$. It's evident that it's mapping from $L\langle A, > \text{to } L$. Every element of L is the finite unit of D-points. So, the inclusion $X \subseteq Y$ is equivalent to the inequality $\vee X \leq \vee Y$. Hence, φ is the one to one surjection and φ and φ^{-1} both are monotone maps. It means that φ is isomorphism.

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REFERENCES

1. *G.Gratzer*. General lattice theory, Academie-Verlag Berlin, 1978.

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MATHEMATICS

D. Leladze

On Summability of Certain Subsequences of Partial Sums of Multiple Trigonometric Fourier Series

Presented by Academician L.Zhizhiashvili, December 2, 1997

ABSTRACT. **In the present paper we give the estimate in the terms of partial and mixed moduli of continuity of deviation of multiple arithmetic means of the sequence of rectangular "mixed" (partially usual, partially dyadedic) partial sums of n-multiple trigonometric Fourier series of a function $f \in L^p([-\pi, \pi]^n)$, $n \geq 1$, $p = 1$ or $p = \infty$ ($L^\infty \equiv C$), from f in the norm of L^p.**

Key words: trigonometric Fourier series.

The study of summability of partial sums of trigonometric Fourier series by various regular methods goes back apparently to Z. Zalcwasser [1], who proved, that if $f \in L([-\pi, \pi])$, then

$$\lim_{n\to\infty} \frac{1}{n} \sum_{k=1}^{n} S_{k^2}(x; f) = f(x)$$

almost everywhere. Here $S_m(x; f)$ is the m-th partial sum of the Fourier series $\sigma[f]$ of the function f.

Later on, S. Izumi, R. Salem, L. Carleson, D. Newman, I. A. Zagorodnii, R. M. Trigub, Ja. S. Bugrov and others dealt with similar problems.

D.Newman [2] proved that for any regular method of summability associated with matrix $\|a_{nk}\|$ there exists a function $f \in C([-\pi, \pi])$ such that

$$\lim_{n\to\infty} \sup \left\| \sum_{k=0}^{\infty} a_{nk} S_{2^k}(x; f) \right\|_C = +\infty.$$

On the other hand, as A.Baiarstanova [3] showed, that if $f \in C([-\pi, \pi])$ and its modulus of continuity satisfies the condition

$$\omega(\delta; f)_C = o\left(\ln^{-\frac{1}{2}} \frac{1}{\delta} \right) \quad (\delta \to 0+),$$

then

$$\lim_{n\to\infty} \left\| \frac{1}{n+1} \sum_{k=0}^{n} S_{2^k}(x; f) - f(x) \right\|_C = 0.$$

She also established that analogous statement holds true for $f \in L([-\pi, \pi])$ [4].

In the same papers she proved that these results are the best possible in a certain sense.

Let $f \in L([-\pi, \pi]^n)$, $n \in N$, $n > 1$ be a function, 2π-periodic in each variable and $\sigma_n[f]$ be its n-multiple trigonometric Fourier series [5]).

We set

$$m = (m_1, \dots, m_n) \quad (m_i \in N,\ i = 1, \dots, n);$$

$$x = (x_1, \dots, x_n) \quad (x_i \in R,\ i = 1, \dots, n);\ M = \{m_1, \dots, m_n\}.$$

By M_j we denote the set of all subsets of M with j elements, by $M(A)$ - the set $M \setminus A$ $(A \subset M)$, and by $M_j(A)$ - the set of all subsets of $M(A)$ with j elements.

For $f \in L^p([-\pi, \pi]^n)$, $n \geq 1$, $p = 1$ or $p = \infty$ $(L^\infty \equiv C)$ we consider its mixed modulus of continuity

$$\omega_q(\delta; f)_{L^p} = \sup_{|h_1| \leq \delta_1, \dots, |h_k| \leq \delta_k} \left\| \Delta_k^{h_k}\left(\Delta_{k-1}^{h_{k-1}}\left(\dots\left(\Delta_1^{h_1}(x; f)\right)\dots\right)\right)\right\|_{L^p},$$

where

$$q = \{m_1, \dots, m_k\},\ \delta = \{\delta_1, \dots, \delta_k\},$$

$$\Delta_i^h(x; f) = f(x_1, \dots, x_{i-1}, x_i + h, x_{i+1}, \dots, x_n) - f(x_1, \dots, x_n).$$

We set

$$\tau_m(x; f) = \frac{1}{m_1 + 1} \dots \frac{1}{m_n + 1} \sum_{i_1=0}^{m_1} \dots \sum_{i_n=0}^{m_n} S_{2^{i_1}, \dots, 2^{i_n}}(x; f),$$

where $S_{2^{i_1}, \dots, 2^{i_n}}(x; f)$ is the rectangular partial sum of the series $\sigma_n[f]$.

In the sequel by A, B, etc. we denote, in general, different positive constants.

In [6] we proved the following

Theorem. *Let $f \in L^p([-\pi, \pi]^n)$, $n \geq 1$, $p = 1$ or $p = \infty$ $(L^\infty \equiv C)$. Then*

$$\left\|\tau_m(x; f) - f(x)\right\|_{L^p} \leq A \sum_{j=1}^{n} \sum_{q \in M_j} \frac{1}{\sqrt{\prod_{k=1}^{j} m_{i_k}}} \omega_q\left(\frac{1}{2^q}; f\right)_{L^p}, \tag{1}$$

where $\{m_{i_1}, \dots, m_{i_j}\} \in M_j$.

In the same paper we proved that this result is the best possible in a certain sense.

In the present paper we give the estimate analogous to (1) for multiple arithmetic means of the sequence of "mixed" partial sums of n-multiple trigonometric Fourier series of a function $f \in L^p([-\pi, \pi]^n)$, $n \geq 1$, $p = 1$ or $p = \infty$ $(L^\infty \equiv C)$.

Now we set

$$\tau_{A, M(A)}(x; f) = \frac{1}{m_1 + 1} \dots \frac{1}{m_n + 1} \sum_{i_{k_1}=0}^{m_{k_1}} \dots \sum_{i_{k_n}=0}^{m_{k_n}} S_{A, M(A)}(x; f),$$

where

$$S_{A,M(A)}(x;f) = S_{i_{k_1},\dots,i_{k_j},2^{i_{k_j+1}},2^{i_{k_n}}}(x;f),$$

$$\{m_{i_{k_1}},\dots,m_{i_{k_j}}\} = A, \quad \{m_{i_{k_{j+1}}},\dots,m_{i_{k_n}}\} = M(A).$$

The following is true:

Theorem 1. *Let $f \in L^p([-\pi,\pi]^n)$, $n \geq 1$, $p = 1$ or $p = \infty$ $(L^\infty \equiv C)$. Then*

$$\left\|\tau_{A,M(A)}(x;f) - f(x)\right\|_{L^p} \leq B\sum_{j=1}^{n}\sum_{q\in M_j}\frac{1}{\prod_{k=1}^{j} m_{i_k}}\frac{1}{\sqrt{\prod_{\substack{k=1\\ m_{i_k}\in q\cap M(A)}}^{j} m_{i_k}}}\omega_q\left(\frac{1}{q'};f\right)_{L^p},$$

where, if we set $l_k = m_{i_k}$ for $m_{i_k} \in q \cap A$ and $r_k = m_{i_k}$ for $m_{i_k} \in q \cap M(A)$, then for $q \in M_j$ and $q = \{l_1,\dots,l_s,r_{s+1},\dots,r_j\}$ we denote $q' = \{l_1,\dots,l_s,2^{r_{s+1}},\dots,2^{r_j}\}$.

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REFERENCES

1. *Z.Zalcwasser*. Studia Math., **6**, 1936, 82-88.
2. *D.J.Newman*. Proc. Amer. Math. Soc., **45**, 1974, 300-302.
3. *A.S.Baiarstanova*. Sib. Mathem. Journ., **20**, 1979, 1183-1197 (Russian).
4. *A.S.Baiarstanova*. Vestn. Mosc. Gos. Univ., series math. and mech., **1**, 1980, 29-33 (Russian).
5. *A.Zygmund*. Trigonometric series. I, Univ. Press, Cambridge, 1959.
6. *D.V.Leladze*. Analysis Mathematica, **17**, 1991, 281-295.

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MATHEMATICS

L. Jijeishvili

Summability by Regular Methods of Multiple Series with Respect to Haar-type Systems

Presented by Academician L.Zhizhiashvili, December 2, 1997.

ABSTRACT. **Theorems concerning the summability on a set of positive measure by regular methods of multiple series with respect to Haar-type systems are stated.**

Key words: multiple orthogonal series, Haar-type systems, summability by regular methods.

1. The results of P.L.Ul'yanov [1] concerning the problems of convergence on a set of positive measure of series with monotone-like coefficient sequences are generalized by G.Chkhaidze [2] (for summability by regular methods) and by E.Vlasova [3] (for Haar-type systems of N.Vilevkin [4]). The paper [5] deals with generalization in both these directions simultaneously. The theorems below are the multidimensional analogues of corresponding ones of [5]. They generalize the results of G.Chkhaidze [6] and of E.Vlasova [3] for multiple Haar-type systems.

2. Let N^d ($\overline{N}^d$) be the set of points of Euclidean space R^d with positive (non-negative) integer coordinates. If

$$\mathbf{x} = (x_1, \dots, x_n) \in R^d$$
$$\mathbf{y} = (y_1, \dots, y_n) \in R^d$$

and $x_j \le y_j$ ($x_j < y_j$) for $j = 1, \dots, d$, then we write $\mathbf{x} \le \mathbf{y}$ ($\mathbf{x} < \mathbf{y}$). If $\mathbf{x} \le \mathbf{y}$, then by $(\mathbf{x}, \mathbf{y}]$ is denoted the set of all $\mathbf{t} \in R^d$ satisfying

$$\begin{cases} x_j = t_j = y_j, & \text{if } x_j = y_j, \\ x_j < t_j \le y_j, & \text{if } x_j < y_j, \end{cases} \qquad j = 1, \dots, d.$$

We also use the notations:

$$[\mathbf{x}, \mathbf{y}] = \{\mathbf{t} \in \mathbf{N}^d : \mathbf{x} \le \mathbf{t} \le \mathbf{y}\};\ \mathbf{0} = (0, \dots, 0);\ \mathbf{e} = (1, \dots, 1);$$

$$\mathbf{e}_j = (\delta_{1j}, \dots, \delta_{dj}),\ j = 1, 2, \dots, d, \text{ where } \delta_{ij} = \begin{cases} 1, & i = j \\ 0, & i \ne j; \end{cases}$$

$$\mathbf{H}^j_{\{1\}} = \{\mathbf{x} \in R^d : \mathbf{x}_j = 1\},\ j = 1, \dots, d.$$

Everywhere below we consider the convergence of multiple sequences and series in the sense of Pringsheim.

In what follows we assume, that $\mathbf{P}_n = \left(p_1^{(n)}, \dots, p_d^{(n)}\right)$, $n = 1, 2, \dots$, is some sequence of points of $\mathbf{N}^d$ with $\mathbf{p}_n \ge 2 \cdot \mathbf{e}$ for each $n \in N$. We also put

$$m_i^{(0)} = 0,\ m_i^{(1)} = p_i^{(1)},\ m_i^{(k+1)} = m_i^{(k)} \cdot p_i^{(k+1)} \text{ for } 1 \le k < \infty,\ 1 \le i \le d,$$

$$\mathbf{m}_\mathbf{k} = \left(m_1^{(k_1)}, \dots, m_d^{(k_d)}\right) \text{ for } \mathbf{k} = (k_1, \dots, k_d).$$

One say that d-fold sequence $\{b_{\mathbf{m}}\}_{\mathbf{m}\in N^d}$ belongs to the class $\overline{\mathbf{A}^d}\{\mathbf{p}_n\}$, if there exists $C \geq 1$ such that for any $\mathbf{k} \in \overline{N}^d$ and $\mathbf{r} \in [\mathbf{0}, \mathbf{e}]\backslash\{\mathbf{0}\}$

$$\max_{\mathbf{m}\in(\mathbf{m}_\mathbf{k}, \mathbf{m}_{\mathbf{k}+\mathbf{r}}]} |b_{\mathbf{m}}| \leq C \min_{\mathbf{m}\in(\mathbf{m}_{\mathbf{k}-\mathbf{r}}, \mathbf{m}_\mathbf{k}]} |b_{\mathbf{m}}|$$

and

$$\sum_{\mathbf{m}=\mathbf{e}}^{\infty} b_{\mathbf{m}}^2 Ind_{\mathrm{H}_{(1)}^j}(\mathbf{m}) < \infty, \quad j = 1, \ldots, d.$$

The d-fold Haar-type system $\chi \equiv \chi\{\mathbf{p}_n\} \equiv \{\chi_{\mathbf{m}}(\mathbf{t})\}_{\mathbf{m}\in N^d}$ is defined in the multiplicative way:

$$\chi_{\mathbf{m}}(\mathbf{t}) = \prod_{j=1}^{d} \chi_{m_j}(t_j),$$

for $\mathbf{m} = (m_1, \ldots, m_d) \in \mathbf{N}^d$ and $\mathbf{t} = (t_1, \ldots, t_d) \in [0, 1]^d$, where $\chi_{m_j}(t_j)$ are the functions of single (original) Haar-type system [4].

Let $\dfrac{\Delta^{(1)}}{\mathbf{e}_j}$ be the linear operation on the set $\mathbf{Z}_d$ of all d-fold sequences defined by the following rule: for each $\{u_{\mathbf{m}}\} \in \mathbf{Z}_d$

$$\frac{\Delta^{(1)}}{\mathbf{e}_j}(u_{\mathbf{m}}) = u_{\mathbf{m}} - u_{\mathbf{m}+\mathbf{e}_j}, \quad \mathbf{m} \in N^d, \quad j = 1, \ldots, d.$$

The product of operations $\dfrac{\Delta^{(1)}}{\mathbf{e}_{j_1}}, \ldots, \dfrac{\Delta^{(1)}}{\mathbf{e}_{j_p}}$ is denoted by $\dfrac{\Delta^{(p)}}{\mathbf{e}_{j_1}\ldots\mathbf{e}_{j_p}}$.

One say that a d-fold sequence $\{u_{\mathbf{m}}\}_{\mathbf{m}\in N^d}$ belongs to $\mathbf{M}^d$, if for each fixed $\mathbf{n} \in N^d$ and for each $\mathbf{m} \in \mathbf{N}^d$ holds

$$\frac{\Delta^{(d)}}{\mathbf{e}_1\ldots\mathbf{e}_d}(u_{\mathbf{m}} \mathrm{Ind}_{[\mathbf{e},\mathbf{n}]}(\mathbf{m})) \geq 0.$$

Let $\overline{\mathbf{M}}^d\{\mathbf{p}_n\}$ defined for each $l \in \mathbf{N}^d$ be the set of d - folds sequences $\mathbf{T} = \{\mathbf{R}_{\mathbf{m}}(l)\}_{\mathbf{m}\in N^d}$, such that

a) $\{\mathbf{R}_{\mathbf{m}}(l)\} \in \mathbf{M}^d\{\mathbf{p}_n\}$ for fixed $l \in N^d$,

b) $\lim\limits_{l\to+\infty} \mathbf{R}_{\mathbf{m}}(l) = 1$ for $\mathbf{m} \in N^d$.

If $\{u_{\mathbf{m}}\}_{\mathbf{m}\in N^d}$ be a sequence of real numbers, for each $l \in N^d$ the series $\sum\limits_{\mathbf{m}=\mathbf{e}}^{\infty} u_{\mathbf{m}}\mathbf{R}_{\mathbf{m}}(l)$ converges and there exists

$$\lim_{l\to+\infty} \tau_l \equiv \lim_{l\to\infty} \sum_{\mathbf{m}=\mathbf{e}}^{\infty} u_{\mathbf{m}}\mathbf{R}_{\mathbf{m}}(l) = S,$$

then one say that series $\sum_{m=e}^{\infty} u_m$ is **T**-summable to number S.

3. Following statements are true.

Theorem 1. *Let* $\chi \equiv \chi\{\mathbf{p}_n\}$ *be the multiple Haar-type system,* $\mathbf{T} = \{\mathbf{R}_m(l)\} \in \overline{\mathbf{M}^d}\{\mathbf{p}_n\}$, $\{b_m\} \in \overline{\mathbf{A}^d}\{\mathbf{p}_n\}$, $\sum_{m=e}^{\infty} |b_m|^2 = \infty$. *If* **T**-*means* $\tau_l(\mathbf{t}) \equiv \sum_{m=e}^{\infty} b_m \mathbf{R}_m(l)\chi_m(\mathbf{t})$ *of the series*

$$\sum_{m=e}^{\infty} b_m \chi_m(\mathbf{t}) \tag{1}$$

are determined on a set $\mathbf{E} \in [0, 1]^d$ *of positive measure, then*

$$\operatorname{mes}\left\{\mathbf{t}: \ \mathbf{t} \in \mathbf{E} \ \ |\tau_l(\mathbf{t})| = o\left(\sum_{m=e}^{\infty} b_m^2 \mathbf{R}_m(\mathbf{t})^2\right)^{\frac{1}{2}}\right\} = 0.$$

Corollary. If the conditions of Theorem 1 are fulfilled, then for every monotone increasing to infinity sequence $\{\mathbf{q_k}\}_{k=1}^{\infty} \in \mathbf{Z}^d$

$$\lim_{k\to\infty} \sup \left| \sum_{m=e}^{\mathbf{q_k}} b_m \chi_m(t) \right| = +\infty$$

at almost all $\mathbf{t} \in \mathbf{E}$.

Theorem 2. *Let* $\chi \equiv \chi\{\mathbf{p}_n\}$ *be the multiple Haar-type system,* $\mathbf{T} \equiv \{\mathbf{R}_m(l)\} \in \overline{\mathbf{M}^d}\{\mathbf{p}_n\}$, $\{b_m\} \in \overline{\mathbf{A}^d}\{\mathbf{p}_n\}$, $\sum_{m=e}^{\infty} |b_m|^2 = \infty$. *If* **T**-*means* $\tau_l(\mathbf{t}) = \sum_{m=e}^{\infty} b_m \mathbf{R}_m(l)\chi_m(\mathbf{t})$ *of series* (1) *are determined on a set* $\mathbf{E} \in [0, 1]^d$ *of positive measure and for each* $\mathbf{t} \in \mathbf{E}$.

$$\overline{\lim_{l\to\infty}} |\tau_l(\mathbf{t})| < \infty$$

then (1) *is the Fourier series with respect to the system* χ *of some function*

$$f \in \bigcap_{p=1}^{\infty} L^p[0,1]^d.$$

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REFERENCES

1. *P.L.Ul'yanov.* Izv. AN SSSR Ser. Mat. 28, 1964, 925-950 (Russian).
2. *G.A.Chkhaidze.* In: Some Problems of Theory of Functions, **2**, Tbilisi, 1981, 110-127 (Russian).
3. *E.A.Vlasova.* Izv. Vuzov, Mat. 9, 1990, 3-13 (Russian).
4. *N.Y.Vilenkin.* Izv. AN SSSR Ser. mat. 11, 1947, 363-400 (Russian).
5. *L.R.Jijeishvili.* Bull. Georg. Acad. Sci. **156**, 3, 1997, 374-376.
6. *G.A.Chkhaidze.* In: Some Problems of Theory of Functions, **2**, Tbilisi, 1981, 128-163 (Russian).

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MATHEMATICS

I. Gabisonija, A. Meskhi

Two-Weight Inequalities for Discrete Hardy-Type and Hilbert Transforms

Presented by Corr. Member of the Academy V. Kokilashvili, December 15, 1997

ABSTRACT. **The necessary and sufficient conditions for the pairs of increasing weight sequences ensuring the validity of two –weight inequalities for discrete Hilbert transform are derived.**

Key words: Hardy-type transform, Hilbert transform two-weight inequality, weight.

In the present paper the necessary and sufficient conditions for weight sequences ensuring the validity of two-weight inequalities for discrete Hardy-type transform are derived. Two-weight problems for classical Hardy operator were solved in [1-4]. In this paper there are also established two-weight inequalities for discrete Hilbert transform in the case of increasing weight sequencies. Analogous problems for classical Hilbert transform and for general singular integrals were investigated in [5-9].

We begin with two-weight criteria for discrete Hardy-type transform.

By Z^+ we denote the set of all nonnegative integers.

Theorem 1. *Let $1 < p < q < \infty$, $\{a_n\}$ and $\{b_n\}$ be positive sequencies on Z^+. The inequality*

$$\left(\sum_{n=0}^{\infty} a_n \left|\sum_{k=0}^{n} \beta_k\right|^q\right)^{1/q} \le C\left(\sum_{n=0}^{\infty} |\beta_n|^p\, b_n\right)^{1/p} \tag{1}$$

with the positive constant C independent of $\{\beta_n\}$ holds if and only if

$$A = \sup_{n\ge 0}\left(\sum_{k=n}^{\infty} a_k\right)^{1/q}\left(\sum_{k=0}^{n} b_k^{1-p'}\right)^{1/p'} < \infty, \qquad p' = \frac{p}{p-1},$$

moreover, if C is the best constant in the inequality (1), *then*

$$A \le C \le A\cdot q^{1/q}\cdot (q')^{1/p'}.$$

Theorem 2. *Let $1 < p \le q < \infty$, $\{a_n\}$ and $\{b_n\}$ be positive sequences on Z^+. The inequality*

$$\left(\sum_{n=0}^{\infty} \left|\sum_{k=n}^{\infty} \beta_k\right|^q a_n\right)^{1/q} \le C\left(\sum_{n=0}^{\infty} |\beta_n|^p\, b_n\right)^{1/p}$$

with the positive constant C independent of $\{\beta_n\}$ is fulfilled if and only if

$$\sup_{n\geq 0}\left(\sum_{k=o}^{n} a_k\right)^{1/q}\left(\sum_{k=n}^{\infty} b_k^{1-p'}\right)^{1/p'} < \infty .$$

For the sequence $\{\beta_n\}$ the discrete Hilbert transform is defined in the following way

$$(T\beta)_n = \sum_{k\neq n}\frac{\beta_k}{n-k}.$$

In case when this series diverges we put $(T\beta)_n = \infty$.

Definition. Let $1 < p < \infty$. A positive sequence $\{\rho_k\}$ belongs to $A_p(Z)$, if

$$\sup_{\substack{m,n\\ m\leq n}}\frac{1}{(n-m+1)^p}\left(\sum_{k=m}^{n}\rho_k\right)\left(\sum_{k=m}^{n}\rho_k^{1-p'}\right)^{p-1} < \infty .$$

Further, a sequence $\{\rho_k\}$ belongs to $A_1(Z)$, if there exists a constant $c > 0$, such that the inequality

$$\frac{1}{n-m+1}\sum_{k=m}^{n}\rho_k \leq C \min_{m\leq k\leq n}\rho_k$$

holds for any m and n, $m \leq n$.

One-weight problem for Hilbert transform in classical case as well as in discrete case was solved by R.A. Hunt, B. Muckenhoupt and R. Wheeden [10].

Theorem 3. *Let $1 < p < \infty$ $\{\sigma_n\}$ and $\{u_n\}$ be positive increasing sequences on Z^+ and $\sigma_0 = 0$. Assume that $\{\rho_k\}$ defined on Z^+ and $\{\rho_{|k|}\} \in A_p(Z)$. We put $a_k = \sigma_k\rho_k$, $b_k = u_k\rho_k$. Then if the condition*

$$\sup_{n\geq 0}\left(\sum_{k=n+1}^{\infty}\frac{a_k}{k^p}\right)\left(\sum_{k=0}^{n} b_k^{1-p'}\right)^{p-1} < \infty \tag{2}$$

is fulfilled, then there exists a positive constant C such that the inequality

$$\sum_{k=-\infty}^{+\infty}\left|(T\beta)_k\right|^p a_{|k|} \leq C\sum_{k=-\infty}^{+\infty}\left|\beta_k\right|^p b_{|k|} \tag{3}$$

is valid for any $\{\beta_k\}$.

Conversely, if for positive sequencies $\{a_k\}$ and $\{b_k\}$ the inequality (3) holds, then the condition (2) is satisfied.

Theorem 4. *Let $1 < p < \infty$ $\{\sigma_n\}$ and $\{u_n\}$ be positive sequences on Z^+ with the condition $\sigma_0 = 0$. If the inequality*

$$\sum_{k=-\infty}^{+\infty}\left|(T\beta)_k\right|^p \sigma_{|k|} \leq C\sum_{k=-\infty}^{+\infty}\left|\beta_k\right|^p u_{|k|}$$

with positive constant C independent of $\{\beta_k\}$ is satisfied then there exists a positive con-

stant C_1, $C_1 > 0$ *such that for all* $\{\beta_k\}$ *the inequality*

$$\sum_{k=-\infty}^{+\infty} \left|(T\beta)_k\right|^p \sigma_{|k|}\rho_{|k|} \le C_1 \sum_{k=-\infty}^{+\infty} |\beta_k|^p u_{|k|}\rho_{|k|}$$

holds, where $\{\rho_k\}$ *is defined on* Z^+ *and* $\{\rho_{|k|}\} \in A_1(Z)$.

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REFERENCES

1. *B. Muckenhoupt.* Studia Math. **44**, 1, 1972, 31-38.
2. *V.Kokilashvili.* **Bull.** Acad. Sci. Georgian SSR. **96**, 2, 1979, 37-40 (Russian).
3. *J. S. Bradley.* Canad. Math. Bull. **21**, 1,1978, 405-408.
4. *V.G. Maz'ya.* Sobolev spaces, Springer, Berlin, 1985.
5. *B. Muckenhoupt, R.L. Wheeden.* Studia Math. **55**, 3, 1976, 179-194.
6. *E.G. Gusseinov.* Math. Sb. **132** (174), 1, 1977, 28-44 (Russian).
7. *V. Guliev.* Georgian Math. J. 1, 4, 1994, 367-376.
8. *D.E. Edmunds, V.M. Kokilashvili.* Canad. Math. Bull. **38**, 3, 1995, 295-303.
9. *V. Kokilashvili, A. Meskhi.* Doklady Akademii Nauk, **354**, 3, 1997, 301-303 (Russian).
10. *R.A. Hunt, B. Mackenhoupt, R. Wheeden.* Trans. Amer. Math. Soc. 176, 1973, 227-251.

. "მოამბე", ტ. 158, №2, 1998

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MATHEMATICS

T. Tevzadze

On Estimate of Full Integral Modulus of Smoothness of Function of Several Variables

Presented by Academician L.Zhizhiashvili, November 12, 1997

ABSTRACT. **The theorem with generalized results of M. and Sh. Izumi, of C.Ress and S.Teljakovskii for functions of several variables is stated.**

Key words: K-fold sequence of real variables, K-fold trigonometric Fourier Series, full integral modulus.

1. Let the coefficients of the series

$$f \sim \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos nx \tag{1}$$

and

$$g \sim \sum_{n=1}^{\infty} a_n \sin x \,, \tag{2}$$

satisfy the conditions

$$1)\ \lim_{n\to\infty} a_n = 0, \tag{3}$$

$$2)\ \sum_{n=1}^{\infty} |\Delta a_n| \log(n+1) < +\infty \tag{4}$$

where $\Delta a_n = a_n - a_{n+1}$.

In 1967 C.S.Ress [1] proved, that if $a_n \downarrow 0$, $n \to \infty$ and

$$\sum_{n=1}^{\infty} \frac{a_n}{n} < +\infty,$$

then for integral modulus of continuity of function $f(g)$ the following estimate is true

$$\omega(h; f(g))_1 \le Ah \log \frac{1}{h} \sum_{n \ge \frac{1}{h}} a_n + A \sum_{n > \frac{1}{h}} \frac{a_n}{n}, \tag{5}$$

where A is some positive.

In 1968 M. and Sh. Izumi [2] stated the assertion: If the coefficients of series (1) and

(2) satisfy the conditions (3) and (4), then the following estimate is true:

$$\omega(h; f(g))_1 \le Ah\sum_{n\le\frac{1}{h}} n\,|\Delta a_n|\log(n+1)+A\sum_{n>\frac{1}{h}}|\Delta a_n|\log(n+1). \qquad (6)$$

In 1992 S.A. Teljakovkii [3] generalized estimate (6) for integral modulus of continuity of order $m(m\in N)$.

Analogous question for function of several variables is considered in the article.

2. Let $M=\{1,\cdots,k\}$, B be arbitrary subset of M, $B'=C_M B$; $I_j=(0,\ldots,1,\ldots,0)$, $T^k=[-\pi,\pi]^k$ and

$$\Delta(a_n,\{j\})=a_n-a_{n+I_j},$$

where $(a_n)_n$ is k-fold sequence of real variables. By $\Delta(a_n, B)$ we denote expression which is obtained by successive application of the operation Δ according to those variable indices of which belong to set B.

Let a function $f\in L(T^k)$ be 2π-periodic with respect to each variable and even with respect to variables x_i, $i\in B$ and odd with respect to variables x_j, $j\in B'$. Then, as it is known, the k-fold trigonometric Fourier series has the form

$$\sigma_k[f]\equiv\sum_{n=0}2^{-\lambda(n)}a_n(f)\prod_{i\in B}\cos n_i x_i\prod_{j\in B'}\sin n_j x_j\,, \qquad (7)$$

where $\lambda(\underline{n})$ is the number of those coordinates, which are equal to zero. Here we mention, that if $B=\varnothing$, then the series (7) is called "sine" series and if $B'=\varnothing$, then the series (7) is "cosine" series.

Expression

$$\omega^{(m)}(\underline{\delta};f)_1=\sup_{|\underline{h}|\le\underline{\delta}}\int_{T^k}\Big|\sum_{t=0}^{m}(-1)^{\sum_{j=1}^{k}t_j\nu}\prod_{j=1}^{k}\binom{m_j}{t_j}f\big[\underline{x}+(\underline{m}-2\underline{t})\underline{h}\big]\Big|\,d\underline{x},$$

where $\binom{m_j}{t_j}$ are binomial coefficients, is called full integral modulus of smoothness of order $m(m\in N)$ of function f.

3. The following assertion is true

Theorem. *Let a k-fold sequence of real numbers $(a_n)_{n\ge0}$ satisfy the conditions:*

1) $\lim\limits_{|\underline{n}|\to\infty}a_n=0$,

2) $$\sum_{\underline{n}\geq 0}\prod_{j=1}^{k}\log(n_j+1)\,|\,\Delta(a_{\underline{n}},M)\,|<+\infty,$$

Then for the sum of corresponding "cosine" and "sine" series the following estimate is true

$$\omega^{(\underline{m})}(\underline{h};f)\,|_1\leq$$

$$\leq A(\underline{m})\sum_{B\subset M}\left\{\sum_{n_\mu=1}^{N_\mu}\sum_{n_\nu=N_{\nu+1}}^{\infty}\prod_{\mu\in B}N_\mu^{-m_\mu}n_\mu^{m_\mu}\log(n_\mu+1)\prod_{\nu\in B'}\log(n_\nu+1)\right)|\,\Delta(a_{\underline{n}},M)\,|\Bigg\},$$

$$N_\mu=\left[h_\mu^{-1}\right].$$

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REFERENCES

1. *C.S. Ress.* J. Math. Annal., 19, 1967, 469-474.
2. *M. Izumi , Sh. Izumi.* J. Math. Anal. Appl., 24,1968, 564-581.
3. *S.A. Teljakovskii.* Analysis Math., 19, 1992, 307-323.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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MATHEMATICS

L.Chikvinidze

Local Approximation of Analytic Functions and their Derivatives in Weight Integral Metrics in Domains with a Quasiconformal Boundary

Presented by Corr. Member of the Academy V.Kokilashvili, December 23, 1997

ABSTRACT. **The problem of local polynomial approximation of analytic functions and their derivatives prescribed in finite domains with quasiconformal boundary is investigated in weighted plane integral metrics.**

Key words: Domain with quasiconformal boundary, weighted local polynomial approximation, a weak version of the Muckenhoupt condition.

First results of investigation of the problem dealing with a local polynomial approximation of analytic functions prescribed in finite domains with quasiconformal boundary have been described in [1] for weighted plane integral metrics. Further, this problem is investigated in [2,3], where a constructive description of Hölder classes as well as of some other classes of analytic functions has been obtained. In the present paper we continue investigation of the above-mentioned problem. In particular, the problem of simultaneous polynomial approximation of analytic functions and their derivatives prescribed in finite domains with quasiconformal boundary is investigated in weighted plane integral metrics.

Let G be a finite domain with a quasiconformal boundary $\partial G = \Gamma$ [4], $z_0 \in \Gamma$, $\rho_n(z_0)$ $(n \in N)$ is the distance from the point z_0 to the external level line of the domain G, $U(z_0, r) = \{z: |z - z_0| < r\}$, $c_0 > 0$. Let

$$G(z_0, c_0) = \{z \in G: |\zeta - z| \geq c_0|\zeta - z_0| \quad \forall \zeta \notin G\};$$

$$G_n(z_0, c_0) = G(z_0, c_0) \cup \{U(z_0, \rho_n(z_0)) \cap G\}.$$

The set $G(z_0, c_0)$ is a kind of "nontangential" subset of G with the apex at the point z_0.

Let ω be some weight function (i.e. nonnegative and measurable) defined in the domain G. Let us introduce the notations:

$$L_p(G, \omega) = \{f: |f|^p \in L_1(G)\} \quad (p > 1),$$

$$H^*_p(G, \omega) = \{f: f \text{ holomorphic in } G, f \in L_p(G, \omega)\}.$$

Let $Q = Q(z, a)$ be an open square with a center at the point z, whose sides are parallel to the coordinate axes and have the length a. Let $|Q \cap G| = \sigma(Q \cap G)$ be the plane Lebesgue measure (area) of the set $Q \cap G$, $F(G) \equiv \{Q = Q(z, a): z \in \partial G, a > 0\}$.

We say that the weight function ω, given in the domain G, satisfies the condition $A_p(F(G))$ $(1 < p < \infty)$ (briefly $\omega \in A_p(F(G))$), if

$$\sup_{Q\in F(G)}\left[\frac{1}{|Q\cap G|}\iint_{Q\cap G}\omega(z)d\sigma_z\right]\left[\frac{1}{|Q\cap G|}\iint_{Q\cap G}\omega^{-1/(p-1)}(z)d\sigma_z\right]^{p-1}<\infty.$$

The condition $A_p(F(G))$, introduced first in [5] (in the case where G is the unit circle), is a weakened analogue of the well-known Muckenhoupt condition A_p [6].

Let $\omega\in A_p(F(G))$ $(p>1)$, $\mu\colon \Gamma\times[0;\infty]\to[0;\infty]$ be a function, defined by the equality

$$\mu(z_0,t)=\iint_{Q(z_0,t)\cap G}\omega(z)d\sigma_z \qquad (z_0\in\Gamma,\ t>0). \tag{1}$$

The function $\mu(z_0,t)$ satisfying the conditions [3]:

$$\mu(z_0,2t)\le c\mu(z_0,t) \quad \forall(z_0\in\Gamma,\ t>0),$$

where the constant c does not depend on z_0 and t.

For $\omega\in A_p(F(G))$ $(p>1)$, $f\in L_p(G,\omega)$ we introduce the notations

$$\sigma_p(f,\omega,z_0,t)=\left[\iint_{Q(z_0,t)\cap G}|f(z)|^p\,\omega(z)d\sigma_z\right]^{1/p} \qquad (z_0\in\Gamma,\ t>0);$$

$$\sigma_p(f,\omega,t)=\sup_{z_0\in\Gamma,\,t\le t_0}t_0\mu^{1/p}(z_0,t_0)\int_{t_0}^{\infty}\frac{\sigma_p(f,\omega,z_0,\tau)d\tau}{\tau^2\mu^{1/p}(z_0,\tau)} \qquad (t\ge 0) \tag{2}$$

Similar to the well-known modulus of continuity the function $\sigma_p(f,\omega,\cdot)$ is a continuous nonnegative nondecreasing function satisfying the conditions

$$\sigma_p(f,\omega,\cdot)=0,\ \sigma_p(f,\omega,2t)\le c\sigma_p(f,\omega,t) \quad \forall(t>0),$$

where the constant c does not depend on z_0 and t.

In the sequel, to shorten the writing, we shall use the notation

$$\left[\iint_{G_n(z_0,c_0)}|f(z)|^p\,\omega(z)d\sigma_z\right]^{1/p}\equiv\|f\|_{z_0,p,\omega}$$

Let us now pass to the formulation of the basic results.

Theorem 1. *Let G be a finite domain with a quasiconformal boundary Γ, $\sigma\colon[0;+\infty]\to[0;+\infty]$ be a nonnegative nondecreasing continuos function with the following properties:*

$$\sigma(0)=0, \quad \sigma(2t)\le c\sigma(t) \quad \forall(t>0),$$

where the constant c does not depend on t.

Let $\omega\in A_p(F(G))$, $p>1$, $r\ge 0$ be an integer number, $f^{(r)}\in H_p(G,\omega)$, and $\{P_n^*(z)\}_{n\ge 1}$ be a sequence of algebraic polynomials of order not higher than n such that

$$\|f^{(r)}-P_n^*\|_{z_0,p,\omega}\le c\sigma(\rho_n(z_0)) \quad \forall(z_0\in\Gamma,\ n\in N), \tag{3}$$

where the costant c does not depend on z_0 and n.

Then there exists a sequence of algebraic polynomials P_n of order not higher than n such that for all $k = 0, 1, \dots, r$, $z_0 \in \Gamma$ and $n \in N$ we have the inequality

$$\| f^{(k)} - P_n^{(k)} \|_{z_0,p,\omega} \le c[(\rho_n(z_0))]^{r-k} \sigma(\rho_n(z_0)) \quad \forall (z_0 \in \Gamma,\ n \in N),$$

where the constant c does not depend on z_0 and n.

Ref. [1,3] contains the proof of the fact that if $f^{(r)} \in H^*_p(G, \omega)$ $(p > 1)$, $r \ge 0$, then inequality (3) is fulfilled for $\sigma(t) \equiv \sigma_p(f^{(r)}, \omega, t)$, where $\sigma_p(f^{(r)}, \omega, t)$ is a function defined by equality (2). Thus we arrive at the following result:

Corollary of Theorem 1. *Let G be a finite domain with a quasiconformal boundary Γ, $p > 1$, $\omega \in A_p(F(G))$, $r \ge 0$ is an integer number, $f^{(r)} \in H^*_p(G, \omega)$, $\sigma(f^{(r)}, \omega, t)$ is a function defined by equality* (2). *Then there exists a sequence of algebraic polynomials P_n of order not higer than n such that for all $k = 0, 1, \dots, r$, $z_0 \in \Gamma$ and $n \in N$ we have the inequality*

$$\| f^{(k)} - P_n^{(k)} \|_{z_0,p,\omega} \le c[(\rho_n(z_0))]^{r-k} \sigma(f^{(r)}, \omega, \rho_n(z_0)) \quad \forall (z_0 \in \Gamma,\ n \in N),$$

where the constant c does not depend on z_0 and n.

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REFERENCES

1. *L.N.Chikvinidze*. Siberian Math. J. **30**, 2, 1989, 306-316.
2. *L.N.Chikvinidze*. Proc. A.Razmadze Math. Inst. 101, 1992, 5-26.
3. *L.N.Chikvinidze*. Georgian Math. J. **3**, 2, 1996, 385-394.
4. *Lars V.Alfors*. Lectures on quasiconformal mappings. Princeton, New Jersey, Toronto, New York, London, 1966.
5. *D.Bekolle and A.Bonami*. C.r.Acad. Sci., Paris **AB286**, 18, 1978, 775-778.
6. *B.Muckenhoupt*. Trans. Amer. Math. Soc. **165**, 1972, 207-226.

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MATHEMATICS

S. Khazhomia

Direct Sum Theorems for Dual Homotopy Functors

Presented by Corr. Member of the Academy N.Berikashvili, December 25, 1997

ABSTRACT. **It is shown that cohomotopy-type functors Π^n have the analogues of direct sum theorems for classical homotopy functors π_n and, simultaneously, the semi-exact sequence of pair in the Π theory is exact in corresponding particular cases.**

Key words: (co)homotopy, cohomology, extention of functors.

Following [1], in [2-4] we have introduced and investigated contravariant functors Π^n from the category K of pairs of topological spaces with base points into the category of Abelian groups (as usual, we shall not indicate the basic points or denote it by*). It should be noted that functors Π^n have some of the basic properties of the Borsuk cohomotopy, but they differ from the latter.

The aim of this paper is to show that functors Π^n have the analogues of direct sum theorems [5] for classical homotopy functors π_n.

Let $(X, A) \in K$. In [2] we obtained the semi-exact sequence

$$\ldots \to \Pi^{n-1}(A, *) \xrightarrow{\delta\#} \Pi^n(X, A, *) \xrightarrow{j\#} \Pi^n(X, *) \xrightarrow{i\#} \Pi^n(A, *) \to \ldots .$$

In general we know only the semi-exactness of this sequence. But, in some particular cases we can show also the exactness. For example, it is so for certain principal fibration [4]. Here we consider the three additional useful cases when we can show the exactness.

For convenience we recall the definition of functors Π^n (for detailes see [2,3]). Let H be the singular integral (co)homology theory. Define for $n > 3$ the full subcategory K_n of K by the conditions: each object of K_n is a pair (X_{n-1}, X^n_{n-1}) of linearly- and simply-connected spaces, satisfying the conditions that $\pi_2(X_{n-1}, X^n_{n-1}) = 1$, the homology modules $H_*(X_{n-1})$ and $H_*(X^n_{n-1})$ are of finite type, $H^i(X_{n-1}, X^n_{n-1}) = 0$, $i < n$, and $H^i(X_{n-1}) = H^i(X^n_{n-1}) = 0$, $0 < i < n-1$. For an object $(X, A) \in K$ consider a set of indices $\omega(X, A; n)$ of all pairs $\alpha = (X_{n-1}, X^n_{n-1}; f)$, where $f: (X_{n-1}, X^n_{n-1}) \to (X, A)$ is a continuous map of K. Let $\omega(X, A; n)$ be ordered as follows: $\alpha < \beta$, where $\beta = (Y_{n-1}, Y^n_{n-1}; g)$ if there is a map

$$\varphi: (X_{n-1}, X^n_{n-1}) \to (Y_{n-1}, Y^n_{n-1})$$

of K_n such that $g\varphi$ and f are homotopic: $g\varphi \sim f$. Assume that $H_\alpha = H^n(X_{n-1}, X^n_{n-1})$ and to every ordered pair $\alpha < \beta$ there corresponds the set of induced homomorphisms $\{\varphi^*\}$ in the H theory. We have obtained an inverse system of the groups H_α with sets of homomorphisms. By definition

$$\Pi^n(X, A) = \varprojlim H_\alpha .$$

We denote by p_α the α-coordinate of an element $p \in \Pi^n(X, A)$ and by CX and SX the

cone and the suspension respectively over a space X in the category K.

Remark. It is not difficult to deduce from [2] that for definition functors Π^n we can use the indices of type $\alpha = (CX_{n-1}, X_{n-1}; f)$ only.

1. Let A (i: $A \to X$) be a retract of X and r: $X \to A$ a corresponding map. Consider an index $\alpha = (CX_{n-1}, X_{n-1}; f) \in \omega(X, A; n)$ and define an index $\alpha_1 = (SX_{n-1}, *; f_1) \in \omega(X, *; n)$ by taking

$$f_1(x, t) = \begin{cases} f(x,2t), & \text{if } 0 \le t \le \frac{1}{2}, \quad x \in X_{n-1}, \\ rf(x,2-2t), & \text{if } \frac{1}{2} \le t \le 1, \quad x \in X_{n-1}. \end{cases}$$

Let e_1: $(CX_{n-1}, X_{n-1}) \to (SX_{n-1}, *)$ be the standard map.

Lemma 1. *For $n > 3$ the formula $[\lambda_1(p)]_\alpha = e_1^{*-1}(p_{\alpha 1})$, where $p \in \Pi^n(X)$, defines a homomorphism λ_1: $\Pi^n(X) \to \Pi^n(X, A)$.*

Using the homomorphisms λ_1 and $r^\#$ we can show that the following proposition is valid (cf.[5]).

Proposition 1. *If A is a retract of X, then for every $n > 3$ the sequence*

$$0 \to \Pi^n(X, A) \xrightarrow{j^\#} \Pi^n(X) \xrightarrow{i^\#} \Pi^n(A) \to 0$$

is exact and $\Pi^n(X) \approx \Pi^n(A) \oplus \Pi^n(X, A)$.

2. Let X be deformable into A (i: $A \to X$) relative to a point $* \in A$ and h_t: $X \to X$ a corresponding homotopy ($h_0 = id_X$, h_1: $X \to A$). Consider an index $\alpha = (X_n, *; f) \in \omega(A, *; n)$ and define an index

$$\alpha_1 = (X_n \times I, X_n \vee X_n; f_1) \in \omega(X, A; n+1)$$

by taking $f_1(x, t) = h_t(f(x))$, where $x \in X_n$, I is the unit segment and $\vee$ denote one-point union of two spaces. Let

$$e_2: (X_n \times I, X_n \vee X_n) \to (CX_n, X_n)$$

be the standard map ($e_2(x, 0) = *$) and δ the coboundary homomorphism of pair (CX_n, X_n) in the H theory.

Lemma 2. *For $n \ge 3$ the formula $[\lambda_2(p)]_\alpha = \delta^{-1} e_2^{*-1}(p_{\alpha 1})$, where $p \in \Pi^{n+1}(X, A)$, defines a homomorphism λ_2: $\Pi^{n+1}(X, A) \to \Pi^n(A)$.*

Using the homomorphisms λ_2 and $h_1^\#$ we can show that the following proposition is valid (cf.[5]).

Proposition 2. *If X is deformable into A relative to a point $* \in A$, then for every $n \ge 3$ the sequence*

$$0 \to \Pi^n(X) \xrightarrow{i^\#} \Pi^n(A) \xrightarrow{\delta^\#} \Pi^{n+1}(X, A) \to 0$$

is exact and $\Pi^n(A) \approx \Pi^n(X) \oplus \Pi^{n+1}(X, A)$.

3. Let A (i: $A \to X$) is contractible in X relative to a point $* \in A$ and h_t: $A \to X$ a corresponding homotopy ($h_0 = i$, $h_1(A) = *$). Consider the indices

$$\alpha = (X_n, *; f) \in \omega(A, *; n),$$

$$\beta = (CY_n,\ Y_n;\ g) \in \omega(X,\ A;\ n+1)$$

and define the indices

$$\alpha_1 = (CX_n,\ X_n;\ f_1) \in \omega(X,\ A;\ n+1),$$

$$\beta_1 = (SY_n,\ *;\ g_1) \in \omega(X,\ *;\ n+1),$$

by taking $f_1(x,\ t) = h_{1-t}(f(x))$, $x \in X_n$:

$$g_1(y,\ t) = \begin{cases} g(y,2t), & \text{if } 0 \le t \le \dfrac{1}{2}, \quad y \in Y_n, \\ h_{2t-1}g(y,1), & \text{if } \dfrac{1}{2} \le t \le 1, \quad y \in Y_n. \end{cases}$$

Let $e_1\colon (CY_n,\ Y_n) \to (SY_n,\ *)$ be the standard map and δ the coboundary homomorphism of pair $(CX_n,\ X_n)$ in the H theory.

Lemma 3. *For $n \ge 3$ the formula $[\lambda_3(\widetilde{p})]_\alpha = \delta^{-1}(p_{\alpha\beta})$, where $\widetilde{p} \in \Pi^{n+1}(X,\ A)$, defines a homomorphism*

$$\lambda_3\colon \Pi^{n+1}(X,\ A) \to \Pi^n(A)$$

and formula $[\lambda_4(p)]_\beta = e^{*-1}(p_{\beta 1})$, where $p \in \Pi^{n+1}(X)$, a homomorphism

$$\lambda_4\colon \Pi^{n+1}(X) \to \Pi^{n+1}(X,\ A).$$

Using the homomorphisms λ_3 and λ_4 we can show that the following proposition is valid (cf.[5]).

Proposition 3. *If A is contractible in X relative to a point $* \in A$, there for every $n \ge 3$ the sequence*

$$0 \to \Pi^n(A) \xrightarrow{\delta\#} \Pi^{n+1}(X,\ A) \xrightarrow{j\#} \Pi^{n+1}(X) \to 0$$

is exact and $\Pi^{n+1}(X,\ A) \approx \Pi^n(A) \oplus \Pi^{n+1}(X)$.

Thus, to obtain direct sum theorems [5] for functors Π^n, we prove simultaneously the exactness of semi-exact sequence of pair in corresponding particular cases.

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REFERENCES

1. *G.S.Chogoshvili.* Bull. Acad. Sci. Georgian SSR. **97**, 2, 1980, 273-276.
2. *S.M.Khazhomia.* Trudy Tbilis. Math. Inst. **91**, 1988, 81-87.
3. *S.M.Khazhomia.* Georgian Math. Journal, **1**, 2, 1994, 151-172.
4. *S.M.Khazhomia.* Georgian Math. Journal, **2**, 1, 1995, 55-77.
5. *S.T.Hu.* Homotopy theory. Academic press. New York and London, 1959.

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MATHEMATICS

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DG Hopf Algebras with Steenrods i-th Coproducts

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ABSTRACT. **In this note we introduce the notion of *DG*-Hopf algebra with Steenrods ∇_i products $(C, d, \mu, \nabla_0, \nabla_1, \ldots)$ where (C, d, μ) is a *DG*-algebra and $\{\nabla_i: C \to C \otimes C\}$ are chain operations, with properties dual to Steenrods $\cup_i$ -products, satisfying some conditions of compatibility with the multiplication $\mu: C \otimes C \to C$. As an example of such structure for the singular cubical chain complex $CU_*(G)$ of a topological monoid G the construction of ∇_i-s is given.**

Key words: Hopf algebra, cup product, cubical cochains.

We are dealing with objects of type $(C, d, \nabla_0, \nabla_1, \nabla_2, \ldots)$ where (C, d) is a *DG* module (to avoid the sign problems all modules are considered over Z_2) with deg $d = -1$ and $\nabla_i: C \to C \otimes C$ are coproducts, satisfying the conditions

$$\deg \nabla_i = i, \quad D\nabla_i = \nabla_{i-1} + T\nabla_{i-1}, \tag{1}$$

here D is the differential in $Hom(C, C \otimes C)$ and $T: C \otimes C \to C \otimes C$ is the permutation map $T(a \otimes b) = b \otimes a$, we also require the coassociativity of ∇_0:

$$(\nabla_0 \otimes id)\nabla_0 = (id \otimes \nabla_0)\nabla_0;$$

such an object we shall call *DG* coalgebra with Steenrods ∇_i-coproducts. For such an object in $C^* = Hom(C, Z_2)$ there appears a structure of *DG*-algebra with Steenrods $\cup_i$-products and in $H(C^*)$ there appear Steenrods squares Sq^i: $H^p(C^*) \to H^{p+i}(C^*)$ in the standard manner.

A morphism of such objects

$$(C, d, \nabla_0, \nabla_1, \nabla_2, \ldots) \to (C', d', \nabla'_0, \nabla'_1, \nabla'_2, \ldots)$$

we define as a collection of homomorphisms

$$\{f, F_1, F_2, \ldots\},$$

where f: $(C, d) \to (C', d')$ is a chain map and each F_i: $C \to C' \otimes C'$ is a homomorphism of degree i satisfying the condition

$$DF_{i+1} = \nabla'_i f + (f \otimes f)\nabla_i + F_i + TF_i;$$

It is not hard to check that in this case the induced homomorphism f^*: $H(C'^*) \to H(C^*)$ preserves Steenrods squares.

Two structures $\{\nabla_i\}$ and $\{\nabla'_i\}$ on (C, d) are equivalent if the identity homomorphism id: $C \to C'$ can be extended to a morphism

$$\{id, F_1, F_2, \ldots\}: (C, d, \nabla_0, \nabla_1, \nabla_2, \ldots) \to (C, d, \nabla'_0, \nabla'_1, \nabla'_2, \ldots);$$

in this case the squares Sq^1 induced on $H(C^*)$ by $\{\nabla_i\}$ and $\{\nabla'_j\}$ respectively coincide.

The main example of DG-coalgebra with Seenrods ∇_i-coproducts is the singular chain complex $C_*(X)$, where ∇_i-s are constructed using acyclic models with starting condition $\nabla_0^* = \Delta$: $H_0(X) \to H_0(X) \otimes H_0(X)$, where Δ is the diagonal map. Note that this structure is unique up to equivalence, mentioned above, a continuous map induces a morphism in above sense. There is the construction of concrete ∇_i-s due to Steenrod.

Suppose now that in addition there is given on C an associative multiplication μ: $C \otimes C \to C$, which turns (C, d, μ) into a DG-algebra, i.e. d is a derivation with respect to μ. We are interested what kind of compatibility of ∇_i-s with μ (i.e. what kind of decomposability of ∇_i on products) should be required in this case.

Usually for ∇_0: $C \to C \otimes C$ it is required, that it must be a multiplicative map, i.e.

$$\nabla_0\mu = \mu_{C\otimes C}(\nabla_0 \otimes \nabla_0),$$

here $\mu_{C\otimes C} = (\mu \otimes \mu)(id \otimes T \otimes id)$ is the induced multiplication on $C \otimes C$. This condition means, that (C, d, μ, ∇_0) is a DG-Hopf algebra. The example of such structure is $C_*(G)$ where G is a topological monoid, say a loop space ΩX.

As for the requirement for the cooperation ∇_1 here works the following argument. The sum of two multiplicative maps $E_0 := \nabla_0 + T\nabla_0$ is no more a multiplicative but it is a $(\nabla_0 - T\nabla_0)$-derivation, i.e.

$$E_0\mu = \mu_{C\otimes C}(E_0 \otimes \nabla_0 + T\nabla_0 \otimes E_0),$$

on the other hand the submodule of $(\nabla_0 - T\nabla_0)$-derivations

$$Der_{(\nabla_0 - T\nabla_0)}(C, C \otimes C) \subset Hom(C, C \otimes C)$$

is closed under the differential D, thus, in order to satisfy the condition $D\nabla_1 = E_0$ (see 1 for $i = 1$) the cooperation ∇_1 must be a $(\nabla_0 - T\nabla_0)$-derivation:

$$\nabla_1\mu = \mu_{C\otimes C}(\nabla_1 \otimes \nabla_0 + T\nabla_0 \otimes \nabla_1);$$

together with $D\nabla_1 = \nabla_0 + T\nabla_0$ this means, that ∇_1 is a derivation homotopy. Note, that this condition for ∇_1 is required in [1].

Let us mention that an object $(C, d, \nabla_0, \nabla_1)$ is a HAH in the sense of [2], homotopy Hopf algebra in sense of [1] and a B_∞-algebra in sence of [3].

The argument for ∇_2 is a bit different. The cooperations ∇_1 and $T\nabla_1$ are $(\nabla_0 - T\nabla_0)$ and $(\nabla_0 - T\nabla_0)$-derivations respectively. Their sum $E_1 := \nabla_1 + T\nabla_1$ is not more a derivation, but it decomposes on products by the rule

$$E_1\mu = \mu_{C\otimes C}(E_1 \otimes \nabla_0 + TE_1 \otimes \nabla_1 + T\nabla_1 \otimes E_0 + \nabla_0 \otimes E_1);$$

the set of maps with such kind of decomposability is not closed with respect to D, but if we require for ∇_2 to be decomposable by the rule

$$\nabla_2\mu = \mu_{C\otimes C}(\nabla_2 \otimes \nabla_0 + T\nabla_1 \otimes \nabla_1 + \nabla_0 \otimes \nabla_2),$$

then it is not hard to check that $D\nabla_2$ decomposes as E_1, thus in order to satisfy the condition $D\nabla_2 = E_1$ (see 1 for $i = 2$) it is natural to require the mentioned decomposability of ∇_2.

The similar argument allows to produce the requirements for higher ∇_i-s:

Definition 1. A DG Hopf algebra with Seenrods ∇_i-coproducts we define as an object $(C, d, \mu, \nabla_0, \nabla_1, \nabla_2, \ldots)$ where (C, d, μ) is a DG algebra, $(C, d, \nabla_0, \nabla_1, \nabla_2, \ldots)$ is a DG coalgebra with Seenrods ∇_i-coproducts and the following compatibility of ∇_i-s with multiplication μ is required:

$$\nabla_n\mu = \sum_{k=0}^{n} \mu_{C\otimes C}(T^k\nabla_{n-k} \otimes \nabla_k). \tag{2}$$

A morphism of such objects

$$\{f, F_1, F_2, \ldots\}: (C, d, \nabla_0, \nabla_1, \nabla_2, \ldots) \to (C', d', \nabla'_0, \nabla'_1, \nabla'_2, \ldots)$$

we define as a morphism of DG coalgebras with Steenrods ∇_i-coproducts, where, in addition, f is multiplicative and each F_n decomposes by the rule

$$F_n\mu = \mu_{C\otimes C}[\sum_{k=0}^{n-1} (f\otimes f)(T^kF_{n-k} \otimes \nabla_k) + \sum_{k=1}^{n} (T^{k+1}\nabla'_{n-k} \otimes F_k)(f\otimes f)].$$

Example. An example of DG Hopf algebra with Steenrods ∇_i-coproducts is singular cubical chain complex of a topological monoid $CU_*(G)$. Note that the singular chain complex $C_*(G)$ is not the case: Steenrods cooperations ∇_i do not satisfy the conditions 2.

The cubical singular chain complex $CU_*(X)$ of a space X is defined as follows: $CU_n(X)$ is the free module generated by singular cubes σ^n: $I^n \to X$ (i.e. by continuous maps $\sigma^n(x_1, \ldots, x_n)$, $x_i \in I$) divided by submodule, generated by degenerated singular cubes (σ is degenerate, if it does not depend on x_i for some i), the boundary operator d: $CU_n(X) \to CU_{n-1}(X)$ is given by $d\sigma^n = \sum_{i=1}^{n}\left(d_i^1 + d_i^0\right)\sigma^n$, where

$$d_i^\epsilon\sigma^n(x_1, \ldots, x_{n-1}) = \sigma^n(x_1, \ldots, x_{i-1}, \epsilon, x_{i+1}, \ldots, x_n), \ \epsilon = 0, 1.$$

In order to specify on $CU_*(X)$ a structure of DG-coalgebra with Seenrods ∇_i-coproducts let us introduce two maps φ_0, φ_1: $\{0, 1\} \to \{0, 1, x\}$ given by

$$\varphi_0(0) = 0, \ \varphi_0(1) = x; \ \varphi_1(0) = x, \ \varphi_1(1) = 1.$$

The coassociative coproduct ∇_0: $CU_*(X) \to CU_*(X) \otimes CU_*(X)$, which turns $CU_*(X)$ into a DG-coalgebra is given by

$$\nabla_0(\sigma^n) = \sum_{(i_1,\ldots,i_n)} \sigma^n[\varphi_0(i_1), \ldots, \varphi_0(i_n)]\otimes\sigma^n[\varphi_1(i_1), \ldots, \varphi_1(i_n)],$$

where the summation is taken over all vertexes $(i_1, \ldots, i_n)$, $i_k = 0, 1$ of I^n. This coproduct coincides with one, given in [4] and in [1].

Let us define the coproduct ∇_1: $CU_*(X) \to CU_*(X) \otimes CU_*(X)$ by

$$\nabla_1(\sigma^n) = \sum_{(i_1,\ldots,i_{k-1},x,i_{k+1},\ldots,i_n)} \sigma^n[\varphi_1(i_1), \ldots, \varphi_1(i_{k-1}), x, \varphi_0(i_{k+1}), \ldots, \varphi_0(i_n)]\otimes$$

$$\otimes\sigma^n[\varphi_0(i_1), \ldots, \varphi_0(i_{k-1}), x_k, \varphi_1(i_{k+1}), \ldots, \varphi_1(i_n)],$$

where the summation is taken over all 1-faces $(i_1, \dots, i_{k-1}, x, i_{k+1}, \dots, i_n)$, $i_k = 0, 1$ of I^n. This coproduct coincides with one given in [1].

Generally, for coproducts $\nabla_s: CU_*(X) \to CU_*(X) \otimes CU_*(X)$ we give the following formula

$$\begin{aligned}\nabla_s(\sigma^n) = \sum \sigma^n\Big[&\varphi_s(i_1), \dots, \varphi_s(i_{k_1-1}), x, \varphi_{s-1}(i_{k_1+1}), \dots, \varphi_{s-1}(i_{k_2-1}), x, \varphi_{s-2}(i_{k_2+1}), \dots, \\ &\varphi_1(i_{k_s-1}), x, \varphi_0(i_{k_s+1}), \dots, \varphi_0(i_n)\Big] \otimes \sigma^n\Big[\varphi_{s+1}(i_1), \dots, \varphi_{s+1}(i_{k_1-1}), x, \varphi_s(i_{k_1+1}), \\ &\dots, \varphi_s(i_{k_2-1}), x, \varphi_{s-1}(i_{k_2+1}), \dots, \varphi_2(i_{k_s-1}), x, \varphi_1(i_{k_s+1}), \dots, \varphi_1(i_n)\Big] \end{aligned} \quad (3)$$

where the summation is taken over all s-faces

$$(i_1, \dots, i_{k_1-1}, x, i_{k_1+1}, \dots, i_{k_2-1}, x, i_{k_2+1}, \dots, i_{k_s-1}, x, i_{k_s+1}, \dots, i_n),\ i_k = 0, 1$$

of I^n and $\varphi_k = \varphi_{\text{kmod}2}$.

Proposition 1. *The coproducts ∇_s given by* 3 *satisfy the condition* 1, *thus they specify on $CU_*(X)$ the structure of DG-coalgebra with Steenrods ∇_i-coproducts.*

Suppose now, that G is a topological monoid, then the operation $G \times G \to G$ induces the multiplication

$$\mu: CU_*(G) \to CU_*(G) \otimes CU_*(G)$$

given by

$$\mu(\sigma^n \otimes \tau^m)(x_1, \dots, x_{n+m}) = \sigma^n(x_1, \dots, x_n) \cdot \tau^m(x_{n+1}, \dots, x_{n+m});$$

this multiplication turns $CU_*(G)$ into a DG-algebra.

Proposition 2. *The coproducts ∇_s given by* 3 *satisfy the condition* 2, *thus they specify on $CU_*(G)$ the structure of DG Hopf algebra with Steenrods ∇_i-coproducts.*

Remark. The formula (3) can be rewritten in terms of boundary operators d_i^x:

$$\nabla_s(\sigma^n) = \sum d_1^{\varphi_s(i_1)} d_2^{\varphi_s(i_2)} \dots d_{i_{k_1-1}}^{\varphi_s(i_{k_1-1})} d_{i_k}^x d_{i_{k_1+1}}^{\varphi_{s-1}(i_{k_1+1})} \dots$$

$$\begin{aligned} &d_{i_{k_2-1}}^{\varphi_{s-1}(i_{k_2-1})} d_{i_{k_2}}^x d_{i_{k_2+1}}^{\varphi_{s-2}(i_{k_2+1})} \dots d_{i_{k_s-1}}^{\varphi_1(i_{k_s-1})} d_{i_{k_s}}^x d_{i_{k_s+1}}^{\varphi_0(i_{k_s+1})} \dots d_n^{\varphi_0(i_n)} \sigma^n \otimes d_1^{\varphi_{s+1}(i_1)} d_2^{\varphi_{s-1}(i_2)} \dots \\ &d_{i_{k_1-1}}^{\varphi_{s+1}(i_{k_1-1})} d_{i_k}^x d_{i_{k_1+1}}^{\varphi_s(i_{k_1+1})} \dots {}^{\varphi_s(i_{k_2-1})}_{i_{k_2-1}} d_{i_{k_2}}^x d_{i_{k_2+1}}^{\varphi_{s-1}(i_{k_2+1})} \dots d_{i_{k_s-1}}^{\varphi_2(i_{k_s-1})} d_{i_{k_s}}^x d_{i_{k_s+1}}^{\varphi_1(i_{k_s+1})} \dots d_n^{\varphi_1(i_n)} \sigma^n \end{aligned} \quad (4)$$

here we assume $d_x^k = id$, and, as above the summation is taken over all s-faces

$$(i_1, \dots, i_{k_1-1}, x, i_{k_1+1}, \dots, i_{k_2-1}, x, i_{k_2+1}, \dots, i_{k_s-1}, x, i_{k_s+1}, \dots, i_n),\ i_k = 0, 1$$

of I^n and $\varphi_k = \varphi_{\text{kmod}2}$. This formula determines the coproducts ∇_s not only in $CU_*(X)$ but in chain complex $C_*(Q)$ of an arbitrary cubical set Q. The proposition 1, as well as the Proposition 2, (when Q is a cubical monoid) remain true.

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REFERENCES

1. *H.J.Baues*. The cobar construction as a Hopf algebra. Preprint.
2. *D.J.Amick*. J. of the AMS. 2, 1989, 417-443.
3. *E.Getzler, J.D.Jones*. Operads, homotopy algebra, and iterated integrals for double loop spaces. Preprint, 1985.
4. *J.P.Serre*. Ann. Math. 54, 1951, 429-505.

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MATHEMATICS

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Asymptotics of Solutions to a Pseudodifferential Equations

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ABSTRACT. **A complete asymptotics of the solution to an elliptic system of pseudodifferential equations is investigated by means of the the Wiener-Hopf method (L_p-theory). The obtained asymptotic expansions are written in a matrix form.**

Key words: pseudodifferential equations, asymptotic expansion, Wiener-Hopf method.

In the present paper we investigate a complete asymptotics of the solution φ_0 to system of pseudodifferential equations by means of the Wiener-Hopf method (L_p-theory). The obtained asymptotic expansions are written in a matrix form.

By using the Wiener-Hopf method G. Eskin and J. Bennish have studied a complete asymptotics of solutions of pseudodifferential equations (L_2-theory) [1,2].

We define anisotropic Bessel potential spaces with weight, similar to [2].

Let $\mu, s \in \mathbb{R}$, $m \in \mathbb{N}_0$ and $1 < p < \infty$; by $\mathrm{H}_p^{(\mu,s),m}(\mathbb{R}^n)$ we denote the space of functions (of distributions when $\mu < 0$ or $\mu + s < 0$) endowed with the norm

$$\|u\|_p^{(\mu,s),m} = \|u|\mathrm{H}_p^{(\mu,s),m}(\mathbb{R}^n)\| = \sum_{k=0}^{m} \|< D' >^{\mu} < D >^{s+k} \omega_n^k u \big| L_p(\mathbb{R}^n)\|,$$

$$\omega_n(x) = \frac{x_n}{< x_n >},\ x = (x', x_n) \in \mathbb{R}^n,\ < x_n > = (1 + |x_n|^2)^{1/2},$$

$$\xi' = (\xi_1, \dots, \xi_{n-1}) \in \mathbb{R}^{n-1},\ \xi = (\xi', \xi_n) \in \mathbb{R}^n,$$

$$< \xi' >^{\mu} = (1 + |\xi'|^2)^{\mu/2},\ < \xi >^{\frac{s+k}{2}} = (1 + |\xi|^2)^{\frac{s+k}{2}}.$$

Let $\mathcal{M}$ be a compact n-dimensional C^{∞}-smooth manifold with the C^{∞}-smooth boundary $\partial\mathcal{M}$ and consider $N \times N$ system of pseudodifferential equations

$$r_{\mathcal{M}}\, \mathbf{a}(x, D)u = \mathrm{v}, \tag{1}$$

$$u \in \widetilde{\mathrm{H}}_p^{(\infty,\, s),\infty}(\mathcal{M}),\ \mathrm{v} \in \mathrm{H}_p^{(\infty,\, s-\nu),\infty}(\mathcal{M}),\ s \in \mathbb{R}$$

with a symbol $a \in \mathcal{R}^{\nu}(\mathcal{T}^*\mathcal{M})\mathbf{H}$ [3].

We suppose the homogeneous principal symbol $a_{pr}(x, \xi)$ is elliptic

$$\inf_{\substack{x \in \mathcal{M} \\ |\omega|=1}} |\det a_{pr}(x, \omega)| > 0$$

and consider the matrix

$$a_0 = a_0(x') := [a_{pr}(x', +1)]^{-1} a_{pr}(x', -1),$$

$$a_{pr}(x', \pm 1) := a_{pr}(x', 0, \dots, 0, \pm 1),\ x' \in \partial\mathcal{U}_{x'}.$$

Let $\lambda_1(x'), \dots, \lambda_\ell(x')$ be all eigenvalues of the matrix $a_0(x')$ with the Riesz indices $m_1(x'), \dots, m_\ell(x')$, respectively (i.e. $\lambda_j(x')$ defines $m_j(x')$ linearly independent associated vectors for $a_0(x')$; [4]) and

$$\delta_j = \delta_j(x') := \frac{1}{2\pi i} \log \lambda_j(x'), \quad j = 1, \dots, \ell.$$

Then $\sum_{j=1}^{\ell} m_j = N$ and $a_0(x')$ has the following representation in the normal Jordan form

$$a_0(x') = \mathcal{K}(x') \mathcal{J}_{a_0} \mathcal{K}^{-1}(x'), \ \det \mathcal{K}(x') \neq 0,\ x' \in \partial\mathcal{U}_{x'}, \tag{2}$$

where

$$\mathcal{J}_{a_0} := \operatorname{diag}\{\lambda_1(x') B^{m_1}(1), \dots, \lambda_\ell(x') B^{m_\ell}(1)\}$$

and $B^{m_j}(t)$ are the Jordan blocks defined as follows

$$B^m(t) = \|b_{jk}(t)\|_{m \times m},\ b_{jk}(t) = \begin{cases} \dfrac{t^{k-j}}{(k-j)!}, & j < k, \\ 1, & j = k, \\ 0, & j > k. \end{cases} \tag{3}$$

These matrices are upper triangular (truncated Töplitz matrices)

$$B^m(t) = \begin{pmatrix} 1 & t & \dfrac{t^2}{2!} & \cdots & \dfrac{t^{m-2}}{(m-2)!} & \dfrac{t^{m-1}}{(m-1)!} \\ 0 & 1 & t & \cdots & \dfrac{t^{m-3}}{(m-3)!} & \dfrac{t^{m-2}}{(m-2)!} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & \cdots & 1 & t \\ 0 & 0 & 0 & \cdots & 0 & 1 \end{pmatrix}$$

Let

$$B^0_{a_{pr}}(t) := \operatorname{diag}\{B^{m_1}(t\ \ ), \dots, B^{m_\ell}(t)\} \tag{4}$$

Note, that $B^0_{a_{pr}}(t) := I$ is the identity matrix and $\mathcal{K} \in C^{\infty}(\partial\mathcal{U}_{x'})$, if all chains are trivial $m_1 = \dots = m_\ell = 1$. This is the case when, for example, $a_0(x')$ is a normal matrix.

Let us introduce a special local coordinate system (s.l.c.s.) $(x', x_{n,+}) \in \mathcal{M}^+ = \partial\mathcal{M} \times \mathbb{R}_+$ on $\mathcal{M}$ in the neighborhood of $\partial\mathcal{M}$, where $x' \in \partial\mathcal{M}$, while $x_{n,+}$ measures the distance to the boundary $\partial\mathcal{M}$.

Theorem 1. *Let equation* (1) *have a unique solution* $u \in \widetilde{\mathbf{H}}_p^{(\infty,\, s),\infty}(\mathcal{M})$ *for each given* $v \in \mathbf{H}_p^{(\infty,\, s-\nu),\infty}(\mathcal{M})$ *for some* $s \in \mathbb{R}$. *Then*

$$\frac{1}{p} - 1 < s - \frac{\nu}{2} - \operatorname{Re}\, \delta_j(x') < \frac{1}{p} \quad \text{for all } j = 1, \ldots, \ell.$$

Let further $\frac{\nu}{2} + \operatorname{Re}\delta_j(x') > -1$, $M \in \mathbb{N}_0$ and $\gamma \geq \left[\frac{n}{2}\right] + M + 4$, $\mathcal{K} \in C^\infty(\partial\mathcal{M})$ and $v \in \mathbf{H}_p^{(\infty,\, s-\nu+M+1),\infty}(\mathcal{M})$. *Then* $\delta_j \in C^\infty(\partial\mathcal{M})$ *and the solution has the asymptotic expansion*

$$u(x', x_{n,+}) = \mathcal{K}(x')\, x_{n,+}^{\frac{\nu}{2}+\Delta(x')} B_{a_{pr}}^0\Big(-\frac{1}{2\pi i}\log x_{n,+}\Big)\, \mathcal{K}^{-1}(x') \times$$

$$\times \left[c_0(x')M + \sum_{k=1}^{M} x_{n,+}^k \sum_{j=0}^{k(2m_0-1)} \log^j x_{n,+}\, c_{kj}(x') \right] + \widetilde{u}_{M+1}(x', x_{n,+}) \tag{5}$$

with $\widetilde{u}_{M+1} \in \widetilde{\mathbf{H}}_{p,comp}^{(\infty,s+M+1),\infty}(\mathcal{M}^+)$, $m_0 = \max\{m_1, \ldots, m_\ell\}$ *for all sufficiently small* $x_{n,+} > 0$. *Here the matrix* $\mathrm{B}_{a_{pr}}^0(t)$ *is defined by the principal symbol of equation* (1). *N-vectors* c_{kj} *belong to* $C^\infty(\partial\mathcal{M})$ *and are influenced by the full symbol of equation* (1).

Furthermore, for arbitrary μ, m, $k \in \mathbb{N}_0$ *the a priori estimates*

$$C_0 \sum_{k=0}^{M}\sum_{j=0}^{k} \left\| c_{kj} \right| C^m(\partial\mathcal{M}) \Big\| + C_0 \Big\| \widetilde{u}_{M+1} \Big| \widetilde{\mathbf{H}}_p^{(\infty,s+M+1),\infty}(\mathcal{M}^+) \Big\| \leq$$

$$\leq \Big\| u \Big| \widetilde{\mathbf{H}}_p^{(\infty,s),\infty}(\mathcal{M}) \Big\| \leq C_1 \Big\| v \Big| \mathbf{H}_p^{(\infty,s-\nu+M),\infty}(\mathcal{M}) \Big\| \leq C_2 \Big\| u \Big| \widetilde{\mathbf{H}}_p^{(\infty,s),\infty}(\mathcal{M}) \Big\|, \tag{6}$$

where $c_{00}(x') = c_0(x')$, *hold with some constants* C_0, C_1 *which are independent of* v.

If chains of associated vectors are trivial $\ell = N$ (*i.e. if* $a_{pr}(x', 0, \pm 1)$ *are positive definite or the matrix* $a_0(x')$ *is normal*; *then for all* $x' \in \partial\mathcal{M}$ *the asymptotic expansion takes the form*

$$u(x', x_{n,+}) = \mathcal{K}(x')\, x_{n,+}^{\frac{\nu}{2}+\Delta(x')}\, \mathcal{K}^{-1}(x') \times$$

$$\times \left[c_0(x') + \sum_{k=1}^{M} x_{n,+}^k \sum_{j=0}^{k} \log^j x_{n,+}\, c_{kj}(x') \right] + \widetilde{u}_{M+1}(x', x_{n,+}). \tag{7}$$

In particular, if chains of associated vectors are trivial and $\delta_1(x') = \cdots = \delta_\ell(x') = \delta(x')$ expansion takes simpler form

$$u(x', x_{n,+}) = x_{n,+}^{\frac{\nu}{2}+\Delta(x')} \left[c_0(x') + \sum_{k=1}^{M} x_{n,+}^{k} \sum_{j=0}^{k} \log^j x_{n,+}\, c_{kj}(x') \right] + \widetilde{u}_{M+1}(x', x_{n,+}) .$$

Note that in the case (7) the Jordan cells are trivial $B^0_{a_{pr}}(t) := I$ and the leading term of the asymptotic expansion contains no logarithms $\log x_{n,+}$.

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REFERENCES

1. *J. Bennish.* J. for Math. Anal. and Appl., **179**, 1993, 417-445.
2. *G.Eskin.* Boundary Value Problems for Elliptic Pseudodifferential Equations AMS, Providence, Rhode Island, 1981.
3. *O.Chkadua, R.Duduchava.* Bericht **11**, 1998. Universität Stuttgart. Preprint.
4. *F.Grantmacher.* Matrix theory. M., 1967.

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MATHEMATICS

S. Saneblidze

Functor D with Coefficients in an Extraordinary Homology Theory

Presented by Corr. Member of the Academy N.Berikashvili, December 29, 1997

ABSTRACT. **For a fibration a twisted tensor product model is constructed in terms of a given chain extraordinary homology theory. As a corollary, a simple proof of R. Thom theorem is obtained.**

Key words: functor D, extraordinary homology theory.

The aim of this paper is twofold: 1. To construct a model for a fibration in terms of given extraordinary homology theory; 2. To give a simple proof of R.Thom theorem [1].

Let $h_*(X, A)$ be an extraordinary homology theory on the category of topological spaces, i.e. h_* satisfies the Eilenberg-Steenrod axioms except possibly for the dimension axiom. A natural question is to decide when is there a functorial chain complex for a homology theory. It appears [2] that if such complex exists, then the theory is automatically degenerated, i.e. it is naturally isomorphic to the singular homology theory with coefficients in $h_*(*)$. We show this fact by a different method which at the same time is available to construct a (Hirsch) model for a fibration, and as a concequence, the Atiyah-Hirzebruch spectral sequence. In particular, we show that the singular non-orientable bordism theory [1] can be given by a chain complex. So the spectral sequence for this theory is degenerated and, thus, we obtain R.Thom theorem which asserts that each mod two singular cycle of a space is homological to a fundamental one of a singular smooth manifold. This proof does not use a notion of the Thom space as well as the Steenrod operations. The main method we use is the perturbation theory developed in [3] (see also [4]), which is modified here to the singular non-orientable bordism theory instead of the (ordinary) singular homology one. Moreover, the method suggests a way to investigate the question that the spectral sequence for the other singular bordism theories is, or not, degenerated.

By a functorial chain complex is meant a functor $L_*(X, A)$ from the category of topological spaces to the category of chain complexes such that the following short sequence of complexes is exact for a pair (X, A)

$$0 \to L_*(A) \to L_*(X) \to L_*(X, A) \to 0.$$

Suppose for a given theory $h_*(X, A)$ we have a functorial chain complex $L_*(X, A)$ with $h_*(X, A) \approx H_*(L(X, A))$. Then we have the following theorems.

Theorem 1. *Let $F \to E \xrightarrow{\xi} X$ be a fibration with the base X finite polyhedron. Then there is a twisted tensor product $(C_*(X) \otimes Rh_*(F), d_\tau)$ and a homology isomorphism*

$$(C_*(X) \otimes Rh_*(F),\ d_\tau) \to L_*(E)$$

which is natural with respect to the base X ($C_*(X)$ *denotes the simplicial chains of* X *and* Rh_* *denotes a free group resolution of* h_*).

In fact, the twisted tensor product is obtained by a twisting cochain

$$\tau \in C^*(X;\ \mathrm{Hom}(Rh_*(F),\ Rh_*(F))),$$

the class, $d(\xi)$, of which is uniquely defined in the set $D(X;\ h_*(F))$ by the fibration ξ. Here $D(-;\ G)$ denotes the functor defined in [3] for a fixed graded group G.

Now the naturality of $d(\xi)$ with respect to an induced fibration applied for the constant map $X \to *$ (and to the constant fibration immediately implies the following (cf. [2])

Theorem 2. *For a finite polyhedron* X, *there is a natural homology isomorphism*

$$(C_*(X) \otimes Rh_*(*),\ d^{\otimes}) \to L_*(X)$$

(*i.e., in Theorem* 1 *a perturbation* $\tau = 0$). *Consequently, there is a natural isomorphism*

$$\Sigma_{p+q=n} H_p(X;\ h_q(*)) \approx h_n(X),$$

and the Atiyah-Hirzebruch spectral sequence for $h_*(X)$ *is degenerated at* E^2 *term.*

Now we construct a chain complex for the singular non-orientable bordism theory $\Omega^O_*(X,\ A)$. Define a chain functor $(L_*(X),\ \partial)$ by

$$L_n(X) = L'_n(X)/L''_n(X),$$

$L'_n(X) = \mathbf{Z}_2[f\colon M^n \to X]$, where M^n is a compact smooth manifold, f is a continuous map, $\partial f = f|M_1^{n-1} + \ldots + f|M_k^{n-1}$, $\partial M^n = M_1^{n-1} \cup \ldots \cup M_k^{n-1}$, $L''_n(X) = \mathrm{Ker}\ \partial \cap L'_n(X)$, $L'_n(X) = Z_n(X) \oplus \bar{L}_n(X)$, $Z_n(X) = \mathbf{Z}_2[f\colon M^n \to X]$, where M^n is connected and ∂M^n is empty.

Theorem 3. *There is a natural isomorphism*

$$\Omega^O_n(X,\ A) \to H_n(L_*(X,\ A)).$$

From Theorems 2 and 3 follows

Theorem 4. (*R.Thom*). *The canonical map*

$$\Omega^O_n(X) \to H_n(X,\ \mathbf{Z}_2)).$$

is epimorphism for a finite polyhedron X.

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REFERENCES

1. *P.E.Conner, E.E.Floyd.* Ergebnisse Tract,' **33**, Springer-Verlag, 1964.
2. *R.O.Burdick, P.E.Conner, E.E.Floyd.* Proc. AMS, **19**, 1968, 1115-1118.
3. *N.Berikashvili.* Proc. A.Razmadze Math. Inst. **51**, 1976, 1-105.
4. *S.Saneblidze.* Proc. A.Razmadze Math. Inst., **111**, 1994, 1-106.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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MECHANICS

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Aspherical Lenses and Focons in Optical Concentrators for Photovoltaic Systems

Presented by Corr. Member of the Academy I. Jebashvili, December 25, 1997

ABSTRACT. **We present the method of calculation of aspherical optic concentrators with various designs for photovoltaic systems. This method is based on spherical interpolation method and it has full adaptation with those technical requirements of digital control machine tools on which the formation of aspherical profiles occurs.**

Key words: photovoltaic cell, double-stage concentrator, focon, spherical interpolation.

In recent years the share of electric energy given by the solar power engineering devices constantly increases. On the one hand, it becomes possible due to the increase efficiency and fall in price of photovoltaic (PV) elements prepared on the basis of different semiconductor compounds (GaAs, Si and others) and on the other hand, due to the different optical concentrators increasing the solar radiation intensity on PV-cells surface [1]. The effective use of optical concentrator is of a great importance in solar energy technology, because it considerably increases PV capacity and reduces the price of electrical energy produced by PV-generators.

The main practical requirements for optical concentrators are: a) high degree of solar radiation concentration; b) minimal spherical aberration; c) high level of concentrated radiation flow homogeneity upon PV-cell surface; d) compactness; e) cheap and simple production technology; f) safety and lasting quality.

To satisfy these requirements different structures of optical concentrators, intended for different kinds of solar devices are designed [2].

Long time scientific and industrial studies are being held at the Scientific Research Institute "OPTICA" in the field of applied aspherical optics. On the basis of these works several designs of optical concentrators with the aspherical profiles have been created.

Among these designs the most simple one is the aspherical plastic lens, concentrating the direct solar radiation onto the separate PV-cell. Our calculation and production technology of aspherical lenses allows: to choose focus distances in the big range of values; to minimize sizes of the solar radiation spot formed by the lens; to achieve a high homogeneity of the concentrated radiation flow; to reduce the lens thickness and mass which is very important for the big sizes concentrators.

The thickness and the mass of our aspherical lenses are by 20 ÷ 30 % less than ordinary spherical lenses with the same optical characteristics. Reduction of the thickness of lens, besides the mechanical importance, has the energetic importance – it reduces the quantity of solar radiation energy, absorbed by the lens materials (mostly optical plastic).

Minimal spherical aberration (up to 3 mm) and 100 % homogeneity of the concentrated beam makes possible to form the homogeneous solar radiation stream with the high degree of concentration (400÷500) on the surface of the given size.

The technique is completely adapted to the specific requirements for form of the software for machine tools with digital control. This enables us to create an automated, cheap and effective technology of serial production of single and double-step optical concentrators for PV-systems.

The mathematical basis of a mentioned method is spherical interpolation [3,4]. On the machine tool with digital control the processing of a smooth profile is realised with the help of spheres formation, the curvature of which as much as possible comes nearer to the curvature of the necessary profile in small area of the given point. Therefore it is much more convenient and easier to calculate coordinate of points of the necessary profile by the method of circular approximation. For realisation of this method we introduce the following discrete parameters:

$$\{R_c, x_c, y_c, x_m, y_m\},$$

where R_c is radius of curvature of a profile in small area of a researched point, (x_c, y_c) is coordinate of center of curvature, (x_m, y_m) is coordinate of a researched point of a required profile. Discreteness of parameters is realized in relation to y coordinate by sizes of Δy values. Let a required profile of aspherical surface be a point with coordinates (x_0, y_0) with appropriate radius of curvature R_c and center of curvature (x_c, y_c), φ_0 be the angle between a return direction of an axis OX and radius- vector of a point (x_0, y_0) (Fig. 1). Our problem is to find a point (x_m, y_m) on a known initial data. We find the center appropriate to this point and radius of curvature so that: 1) The arch of the given circle passed through a points y_0, y_m, y_1, where y_1 is the point followed by step-type behavior after y_m; 2) The beam, put from a point of back of focus F in the opposite direction, after fall on aspherical surface in a point (x_m, y_m) and refraction in a lens, should be passed in parallel axes OX; 3) Beam lines, delivered to the different points of lens surface, form the homogeneous structure in front of the focus F; 4) By recurrence of the given procedure for each discrete point with an interval Δy we can receive a surface, generated from overlapped arches; that the received surface was smooth, without bends of zones, i.e. in each point a required profile has one and the same normal. It is necessary, that tangents of the next arches, in a

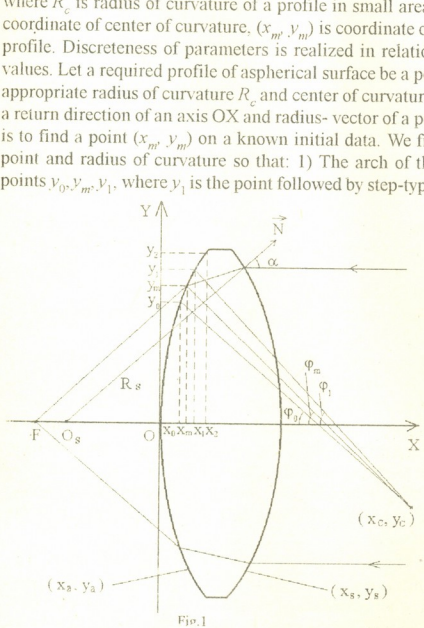

Fig.1

point joining, have identical inclinations to an axis OX .

On the basis of these requirements fulfilment we derive the recurrents formula, which provide the following cyclical transformations:

$$\{x_0, y_0, \varphi_0\} \rightarrow \{x_m, y_m, \varphi_m\} \rightarrow \{x_1, y_1, \varphi_1\} \rightarrow$$

The set of points (x_m, y_m), found from these transformations, forms a profile appropriate to aspherical surface.

To increase the degree of solar radiation concentration factor (ratio of the first working area onto the area of concentrated radiation spot), double- (and multi-) step optical concentrators are used, which usually have the following scheme: direct solar beams reflected from the paraboloidal reflector and geathered in narrow line in the focus of paraboloid; in this place the lenses, i.e. focons are lined and, with the help of them, on the working surface of PV-cell the second concentration of solar radiation takes place. Efficiency of these schemes depends on optical and mechanical characteristics of the second optical concentrators.

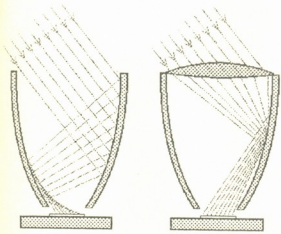

Fig.2

We have designed the double-step optical concentrator, in which the inside mirror covered by empty focon (Fig. 2a) is used for the second concentration of beams. The size of focon in hole is equal to the cross size of the solar radiation line (about 13mm), formed by reflector; and the size of focon out hole is equal to the size of the working surface of PV-cell (about 5mm). Focon wall profile is calculated according to the above mentioned methods. In this case, requrent equations, providing the cyclical transformations (1), are derived on the basis of the following requirements: 1) All beams, which enter focon and have angle of slope up to 24^0 to the axis of symmetry of the focon, must get out from the back side of the focon; 2) The quantity of reflection inside the focon must be minimal; 3) The beam, which come out from the focon, must be homogeneous; 4) The height of focon must be minimal.

As a rule, the simultaneous observance of all these requirements is practically impossible. Our method (with minimal mathematical "loading" and full adaptation to the technical requirements of production) gives us possibility of high effective calculation and production of focons for different needs.

Our model experiments and stand tests demonstrate that the addition of aspherical lens on focon in hole (Fig. 2b) ensure the maximal satisfaction of all requirements and improve some optical and mechanical characteristics.

For example, by selection of lens aspherical profiles we obtained the following results:

1. The increase of beam slope maximal angle to 30^0 (by which reflector net area and concentration coefficient increase).

2. Reduce of requirements to focon profile (by which is simplified the production technology and the operation characteristics of full system improve;

Increase of concentrated stream homogeneity up to 95%.

Based on a given technique we made optical concentrators of a different configuration. Measurements spent on the special stand show that the application of optical concentrators made by our technology, significantly raise capacity of PV-cells.

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REFERENCES

1. *A.W. Bett, S. Keser, G. Stollwerck, et al.* 26th IEEE Photovoltaic Specialists Conference in Anaheim, California, 1997, 137.
2. *M. Brunotte, A.Goetzberger, U. Blieske.* Works of Fraunhofer Institute for Solar Energy Systems, 1996, 1.
3. *J.I. Avaliani, I.I. Kordzakhia, D.M. Shalamberidze, et al.* Raschet i izgotovlenie linzy Frenelya dlya colnechnykh kontsentratorov – Techinform, Tbilisi, 1997 (Russian).
4. *J.I. Avaliani, I.I. Kordzakhia, D.M. Shalamberidze, et al.* Opticheskii kontsetrator solnechnogo izluchenia dlya poluprovodnikovych preobrazovatelei – Techinform, Tbilisi, 1996 (Russian).

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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MECHANICS

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On the Problem of Dynamic Action with a Vertical Load on the Elastic Half Plane Boundary

Presented by Corr. Member of the Academy K. Betaneli, May 15, 1998

ABSTRACT. **The article deals with the regularity of the change of normal and tangential strains of a vertical load on the boundary of elastic half plane in the process of dynamic action.**

Key words: dynamic action, normal strain, tangential strain, vertical load.

Let there be a vertical load on the boundary of elastic half plane (Fig. 1), variation of which is shown by the function $P(x, t)$. Let us assume that the load moves across the axis Ox with a constant velocity C. Vertical V and horizontal $U(x, y, t)$ displacements of the half plane points and normal σ_x and σ_y and tangential strains τ_{xy} are to be found.

We assume that the half plane is a uniform isotropic elastic body and its strained condition is expressed by the equations of elasticity linear theory.

As known [1], in the case when there are no volume forces the elasticity plane theory equations of motion have the following form:

$$\left.\begin{aligned}\frac{\partial\sigma_x}{\partial x}+\frac{\partial\tau_{xy}}{\partial y}&=\rho\frac{\partial^2 u}{\partial t^2},\\ \frac{\partial\tau_{xy}}{\partial x}+\frac{\partial\sigma_y}{\partial y}&=\rho\frac{\partial^2 v}{\partial t^2},\end{aligned}\right\} \tag{1}$$

where

$$\sigma_x=(\lambda+2\mu)\frac{\partial u}{\partial x}+\lambda\frac{\partial v}{\partial y},\quad \sigma_y=(\lambda+2\mu)\frac{\partial v}{\partial y}+\lambda\frac{\partial u}{\partial x},\quad \tau_{xy}=\mu\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right), \tag{2}$$

u and v are components of displacement vector, λ and μ are the Lame parameters. The compatibility condition is as follows

$$\Delta(\sigma_x+\sigma_y)-2\frac{(\lambda+\mu)}{\lambda+2\mu}\rho\frac{\partial^2}{\partial t^2}\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)=0;\ \Delta=\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}. \tag{3}$$

Let us introduce a new function U connected with the strain components by the equation

$$\sigma_x=\frac{\partial^2 U}{\partial y^2}-\frac{\rho}{2\mu}\frac{\partial^2 U}{\partial t^2},\quad \sigma_y=\frac{\partial^2 U}{\partial x^2}-\frac{\rho}{2\mu}\frac{\partial^2 U}{\partial t^2}. \tag{4}$$

Then, as it is known, for the function U we arrive at the differential equation [2]:

$$\left(\Delta-\frac{1}{c_1^2}\frac{\partial^2}{\partial t^2}\right)\left(\Delta-\frac{1}{c_2^2}\frac{\partial^2}{\partial t^2}\right)U=0, \tag{5}$$

where $c_1^2=(\tilde{c}+2\mu)/\rho$ is the velocity of longitudinal wave $c_2^2=\mu/\rho$ is the velocity of the lateral wave and ρ is the density.

As perturbation on the boundary of the elastic body spreads with a constant velocity we can introduce a moving system $x - ct = \xi$, $y = \eta$ of the coordinates $\xi O\eta$. Then the equation (5) will have the form

$$\left[\frac{\partial^2}{\partial\xi^2}+\left(1-\frac{c^2}{c_1^2}\right)\frac{\partial^2}{\partial\eta^2}\right]\left[\frac{\partial^2}{\partial\xi^2}+\left(1-\frac{c^2}{c_2^2}\right)\frac{\partial^2}{\partial\eta^2}\right]U=0. \tag{6}$$

We assume that $c < c_2$ and make a new transformation of the variables

$$\eta_1=\left(1-c^2/c_1^2\right)^{1/2}\eta,\quad \eta_2=\left(1-c^2/c_2^2\right)^{1/2}\eta,\ \xi_1=\xi_2=\xi.$$

We arrive at

$$\left(\frac{\partial^2}{\partial\xi_1^2}+\frac{\partial^2}{\partial\eta_1^2}\right)\left(\frac{\partial^2}{\partial\xi_2^2}+\frac{\partial^2}{\partial\eta_2^2}\right)U=0. \tag{7}$$

Using the formula (4) the strain components in new variables will be:

$$\sigma_x=\frac{\partial^2U}{\partial\eta_1^2}-\frac{c^2}{2c_2^2}\frac{\partial^2U}{\partial\xi^2};\ \sigma_y=\left(1-\frac{c^2}{2c_2^2}\right)\frac{\partial^2U}{\partial\xi^2}. \tag{8}$$

As we can see, (7) is an elliptic differential equation. Its solution, as it follows from the results of [2], can be written as

$$U=2Re[F_1(z_1)+F_2(z_2)], \tag{9}$$

where $z_1=\xi_1+i\eta_1;\ z_2=\xi_2+i\eta_2;\ \xi_1=\xi_2=\xi$.

Proceeding from the above-mentioned, if we take into account the equations (8), the tangential and normal strains can be expressed by the equations

$$\sigma_x=-2\,\mathrm{Re}\left[\left(\frac{c^2}{2c_2^2}+1-\frac{c^2}{c_1^2}\right)F_1^*(z_1)+\left(\frac{1}{2}-\frac{c^2}{2c_2^2}\right)F_2^*(z_2)\right], \tag{10}$$

$$\sigma_y=\left(2+\frac{c^2}{c_2^2}\right)\mathrm{Re}\left[F_1^*(z_1)+F_2^*(z_2)\right], \tag{11}$$

$$\tau_{xy}=2I_m\left[\left(1-c^2/c_1^2\right)F_1^*(z_1)+\sqrt{c_2^2-c^2}/4c_2F_2^*(z_2)\right]. \tag{12}$$

On the boundary $y = 0$ there is a load $P(x,t)$, therefore the boundary conditions have the form:

$$\sigma_y = \left(2 + c^2/c_2^2\right)\mathrm{Re}[F_1''(\xi) + F_2''(\xi)] = -P(x,t);\ \tau_{xy} = 0,\ y = 0. \tag{13}$$

$y = 0$ means that $\eta = 0$ and the equation (12) gives

$$I_m\left[\left(1 - \frac{c^2}{c_1^2}\right)F_1''(\xi) + \frac{\sqrt{c_2^2 - c^2}}{4c_2}F_2''(\xi)\right] = 0. \tag{14}$$

If we recover the real part of the analytical function according to the hypothetic part [4] and take it into account in (13), then we shall have

$$\sigma_x + \sigma_y = 2\left(\frac{c^2}{c_1^2} - \frac{c^2}{c_2^2}\right)\cdot\frac{c_1c_2^2\left(2c_2^2 - c^2\right)}{c_1\left(2c_2^2 - c^2\right)^2 - 4c_2^3\sqrt{\left(c_1^2 - c^2\right)\left(c_2^2 - c^2\right)}}\,\mathrm{Re}\,P(Z_1), \tag{15}$$

$$\tau_{xy} = 2I_m\left(1 - \frac{c^2}{c_1^2}\right)^{1/2}\left[\frac{2 - c^2/c_2^2}{\left(2 - c^2/c_2^2\right)^2 - 4\sqrt{\left(1 - c^2/c_1^2\right)\left(1 - c^2/c_2^2\right)}}\left(P(Z_1) - P(Z_2)\right)\right]. \tag{16}$$

It can be easily seen from the formulae (15) and (16) that the boundary loading and summarized normal strains ($\sigma_x + \sigma_y$) and tangential strains change according to one and the same principle. If the loading for every fixed X and Y increases according to time, then $\sigma_x + \sigma_y$ and τ_{xy} increase too.

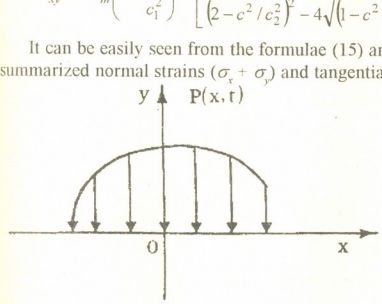

Fig. 1

But if controversially the loading on the boundary for fixed X and Y is reduced according to time then total normal and tangential strains are also reduced. The increase of coordinates X and Y for every fixed time causes the decrease of $(\sigma_x + \sigma_y)$ and σ_{xy}. When X and Y are greatly increased i. e. they tend to infinity, then $(\sigma_x + \sigma_y)$ and τ_{xy} strains tend to zero.

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REFERENCES

1. *N. I. Muskhelishvili.* Nekotorye osnovnye zadachi matematicheskoi teorii uprugosti, M., 1966.
2. *I. N. Sneddon, D. S. Berri.* Klassicheskaia teoriya uprugosti. M., 1961.
3. *S. C. Lekhitskii.* Anizotropnye plastinki. M.-L., 1947.
4. *Lavrentiev, Shabat.* Vvedenie v teoriyu kompleksnogo peremennogo. M.-L., 1972.

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CYBERNETICS

G. Kashmadze

On Evaluation of Membership Function of Fuzzy Set

Presented by Academician V. Chavchanidze, November 3, 1997

ABSTRACT. **The splitting operator which acts in spaces m and l_2 is considered and the norm of the splitting operator is defined. The same norm is introduced in MV-algebra of membership functions of fuzzy sets.**

Key words: fuzzy set, membership function, norm, MV-algebra.

Transition from ordinary sets to fuzzy ones is naturally connected with elements splitting operation from the point of view of possesion of a certain property [1].

Let μ be a mapping of a set N of natural numbers into the $[0,1]$ segment. Define the splitting operator S_μ that maps the space m of limited number sequences into a direct sum $m \oplus m$ as follows:

$$S_\mu(x) = \{\mu x,\ (1-\mu)x\} = \{\mu_i x_i,\ (1-\mu_i)x_i\}_{i=1}^{\infty},$$

where $x \in m$, $\mu \in [0,1]^N$.

Linearity of splitting operator is easy to check.

Introduce a norm of splitting operator:

$$\|S_\mu\| = \sup_{\|x\|\le 1}\|S_\mu(x)\| = \sup_{\|x\|\le 1}\|\{\mu x,(1-\mu)x\}\| = \sup_{\|x\|\le 1}\left[\|\mu x\| + \|(1-\mu)x\|\right] =$$

$$= \sup_{\|x\|\le 1}\left[\sup_i|\mu_i x_i| + \sup_i|(1-\mu_i)x_i|\right] = 1 + \sup_i \mu_i - \inf_i \mu_i.$$

Thus, $\|S_\mu\| \ge 0$, since $0 \le \mu_i \le 1$, $i \in N$.

Following conditions are valid too:

$$\|\alpha S_\mu\| = |\alpha|\,\|S_\mu\| \quad \text{for any real number } \alpha.$$

$$\|S_\mu + S_\nu\| \le \|S_\mu\| + \|S_\nu\|.$$

Assume now that operator acts in space l_2. By using the definition of norm as follows

$$\|S_\mu\| = \sup_{\|x\|\le 1}\left(\sum_{i=1}^{\infty}\mu_i^2 x_i^2\right)^{\frac{1}{2}} + \sup_{\|x\|\le 1}\left(\sum_{i=1}^{\infty}(1-\mu_i)^2 x_i^2\right)^{\frac{1}{2}} = 1 + \sup_i \mu_i - \inf_i \mu_i$$

we get an expression like in space m.

Assume $x, y^I, y^{II} \in l_2$, consider the scalar product [2]

$$\left(S_\mu(x), y\right) = \left(\{\mu x,(1-\mu)x\},\ \{y^I, y^{II}\}\right) = \left(\mu x, y^I\right) +$$

$$+\left((1-\mu)x,\ y^{II}\right)=\sum_{i=1}^{\infty}\mu_i x_i y_i^I+\sum_{i=1}^{\infty}(1-\mu_i)x_i y_i^{II}=$$

$$=\sum_{i=1}^{\infty}x_i(\mu_i y_i^I+(1-\mu_i)y_i^{II})=\left(x,\ S_\mu^*(y)\right).$$

So, splitting operator S_μ has a conjugate one, which is defined on space $l_2 \oplus l_2$ and associates an object $z = \mu y^I + (1 - \mu)y^{II}$ with each pair $y = \{y^I, y^{II}\}$. This operator may be called pasting operator.

Introduce the structure of MV-algebra on the set of splitting operators according to the following definition [3]:

$$S_\mu \oplus S_\nu = S_{\mu\oplus\nu},\ S_\mu * S_\nu = S_{\mu*\nu},\ \overline{S}_\mu = S_{\overline{\mu}},$$

where

$$\mu\oplus\nu=\{\min\{1,\ \mu_i+\nu_i\}\},\ \mu*\nu=\{\max\{0,\ \mu_i+\nu_i-1\}\}.$$

As a result the set of splitting operators which we identify with the set $[0, 1]^N$, becomes a direct sum of enumerable system of MV-algebras $<[0, 1], \oplus, *, -, 0, 1>$.

Introduce in received MV-algebra the same norm

$$\|\mu\|=1+\sup_i\mu_i-\inf_i\mu_i,$$

$$\|\mu\oplus\nu\|=1+\sup_i\{\min\{1,\ \mu_i+\nu_i\}\}-\inf_i\{\min\{1,\ \mu_i+\nu_i\}\},$$

$$\|\mu\|+\|\nu\|=1+\sup_i\mu_i+\sup_i\nu_i+1-(\inf_i\mu_i+\inf_i\nu_i).$$

By comparing the last expressions we get $\|\mu\oplus\nu\|\le\|\mu\|+\|\nu\|$. The following unequality may be proved too: $\|\mu*\nu\|\le\|\mu\|\cdot\|\nu\|$.

The received relations allow to consider a MV-algebra $<[0, 1]^N, \oplus, *, -, 0, 1>$ as normed MV-algebra with $\|\mu\|=1+\sup_i\mu_i-\inf_i\mu_i$.

In common case, when μ is a mapping of any set X into complete lattice an expression $1+\sup_{x\in X}\mu(x)-\inf_{x\in X}\mu(x)$ may be applied as some evaluation of μ together with other criteria [4].

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REFERENCES

1. *T. Gachechiladze, T. Mandjaparashvili.* Trudy TGU. Ser. cib. prikl. math., **279**, 9, 1988, 235 (Russian).
2. *M. A. Naimark.* Normirovannie koltza. Moscow. 1968 (Russian).
3. *C.C.Chang.* Trans. Amer. Math. Soc. , 88, 1958, 467.
4. *T.G. Gachechiladze, G.Sh. Kashmadze.* Bull. Georg. Acad. Sci., **149**, 1, 1994, 38-40 (Russian)

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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PHYSICS

E.Sikharulidze, G.Sikharulidze

Some Peculiarities of Conduction Band Structure of InGaAs

Presented by Academician R.Salukvadze, January 16, 1998

ABSTRACT. **It has been established that the dependence of additional energetic minimum $E_C^{(2)}$ dislocated in conduction band on chemical composition of the material is of nonlinear character. Oscillator force for optic transitions $E_C^{(1)} \rightarrow E_C^{(2)}$, effective mass value $E_C^{(2)}$ of density of state in additional minimum and thermal coefficient value of energetic gap $\Delta_{1,2}$ change have been established.**

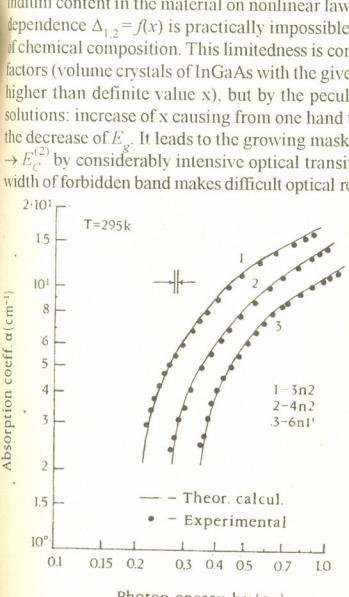
Key words: conduction band, energetic gap, effective mass.

While studying absorption spectra of IR radiation behind the main band edge ($\hbar\omega < \hbar\omega_g$) in monocrystals InGaAs [1] we reported on revealing of electrons transitions from absolute minimum conduction band into some additional minimum of the same band, energetic dislocation of which was estimated by longwave threshold of the established spectral dependence $\alpha_\Delta = f(\hbar\omega)$, connected with transitions $E_C^{(1)} \rightarrow E_C^{(2)}$. The aim of present paper is to obtain more information on these optical transitions and make more precise the peculiarities of structure of $In_xGa_{1-x}As$ solid solutions. The chemical compositions of the studied samples and free electrons concentration in them at $T = 295K$ are indicated in Table. The revealed spectral dependences of absorption coefficient $\alpha_\Delta = f(\hbar\omega)$ in the range of photons energy 0.15÷1.0 eV are illustrated in Fig. (the spectra of those samples which are not close by composition are given in Figure). As it is seen the revealed dependencies $\alpha_\Delta = f(\hbar\omega)$ don't cover the whole spectral range describing electron transitions $E_C^{(1)} \rightarrow E_C^{(2)}$ because long-wave side might not be free from the influence of absorption connected with free charge carriers and the short-wave range due to the proximity to the band of main absorption might be masked by intensive interbands transitions $E_V \rightarrow E_C^{(1)}$. But as there is clearly outlined important range of beginning of saturation absorption coefficient in it, it helps us to judge on the character of intervalley transitions in the band.

Table

Number	Composition x	Free Electrons Concentration Ne(cm^{-3})	$\Delta_{1,2}$ (ev)	m_1^*/m_0	m_2^*/m_0	$f_{1,2}$
2*n*3	0.03	$3.9 \cdot 10^{17}$	0.22	0.056	0.0093	0.43
3*n*2	0.05	$8.2 \cdot 10^{16}$	0.23	0.054	0.0093	0.41
4*n*2	0.09	$3.8 \cdot 10^{17}$	0.27	0.052	0.0094	0.35
5*n*3	0.10	$4.8 \cdot 10^{17}$	0.285	0.052	0.0095	0.33
6*n*1	0.12	$5.2 \cdot 10^{17}$	0.32	0.050	0.0095	0.29

The spectral analysis reveal the features characteristic to indirect optical transitions and the distinct linearity of the dependence $\alpha_{\Delta}^{2}(\hbar\omega)$ testifies to the direct permitted transitions between minima. The revealed character of optical transitions and independence of the refractive index from radiation frequency in the investigated spectral range (at $T = 295K$ for materials of studied compositions and free charge carrier concentrations $n = 3.41$ [2]) makes it possible to determine energetic gap $\Delta_{1,2}$ corresponding to transitions $E_C^{(1)} \rightarrow E_C^{(2)}$ by the dependence $\alpha \sim A'(\hbar\omega - \Delta_{1,2})^{1/2}$, where A' denotes constant. The values $\Delta_{1,2}$ for studied samples are established by gradual correction of the value $\hbar\omega$-th (which was determined by extrapolation of long-wave spectrum range to $\alpha = 0$), up to obtaining of the linear dependence in graphic expression of the above indicated correlation. They are given in Table. (It is taken into account that the values of Fermi level $E_F \leq 0.025$eV.; conduction band near the main minimum is practically parabolic). The construction of the dependence $\Delta_{1,2} = f(x)$ shows that in solid solutions of $In_xGa_{1-x}As$ energetic gap between absolute minimum of conduction band and additional minimum $E_e^{(2)}$ increase with the increase of indium content in the material on nonlinear law. To establish general character of nonlinear dependence $\Delta_{1,2} = f(x)$ is practically impossible due to the limitedness of the studied range of chemical composition. This limitedness is conditioned not only by principal technological factors (volume crystals of InGaAs with the given composition can't be practically obtained higher than definite value x), but by the peculiarities of optical properties of given solid solutions: increase of x causing from one hand the increase of $\Delta_{1,2}$ and from the other hand the decrease of E_g. It leads to the growing masking of low-intensive optical transitions $E_C^{(1)} \rightarrow E_C^{(2)}$ by considerably intensive optical transitions $E_V \rightarrow E_C^{(1)}$. Analogical factor of small width of forbidden band makes difficult optical researches of InAs conduction band structure,



and its knowledge would be useful for the regarded question. In accordance with the obtained data we have all the reasons to suppose that the revealed minimum $E_C^{(2)}$ is dislocated in the center of the Brilluen band (point Γ) or in immediate proximity to it as the researched solid solutions absolute minimum of conduction band is in k-space at $\vec{k} = 0$. The question whether $E_C^{(2)}$ minimum is final or intermediate state for electron transitions can be solved in conditions of monoaxial crystal compression.

The presence of direct, permitted optical transitions between the indicated minima of the band helps to suppose that the observed spectral dependencies of absorption coefficient given in Fig. can be expressed by [3]:

$$\alpha = \frac{2^{3/2} e^2 (m_1^* m_2^*)^{3/2}}{\pi n c m_0 \hbar^2 (m_1^* + m_2^*)^{3/2}} (\hbar\omega - \Delta_{1,2})^{1/2} f_{1,2} \qquad (1)$$

where n is the refractive index at frequency ω; c is the speed of light in vacuum; e and m_0 are charge and mass of electron; m_1^* and m_2^* are the effective masses of density of states in minima correspondingly; and $f_{1,2}$ denotes oscillator force for the given transition (According to electric studies data Hall coefficient in researched spectra doesn't depend on temperature in 78-550K range; electron gas is in degenerated state). One of the main parameters of the expression (1) i.e. the values of effective masses in absolute minimum of band m_1^* for studied samples is determined according to the data of Zeebek effect [4] and they are given in Table. Therefore while chosing corresponding values m_2^* and $f_{1,2}$ resulting in coincidence of calculated curve $\alpha_\Delta(\hbar\omega)$ with experimental one it becomes possible to evaluate the effective mass of density of states in minimum $E_C^{(2)}$ and oscillator force for the given transition. If we take into consideration that by Kein's theory matrix element of P_{if}^{α} is approximately constant for semiconductors with extremums of basic bands at $\vec{k} = 0$ [5], then approximate value of oscillator force can be established from formula $f_{if} = \frac{2}{3} \left| P_{if}^{\alpha} \right|^2 m^{-1} (\hbar\omega_{if})^{-1}$ [4] as the determining parameter of matrix element $P = 8.6 \cdot 10^{-8}$ eV cm for the given solid solutions is known [6]. By weak correction of value $f_{1,2}$ and chosing the suitable value m_2^*, until complete coincidence of calculated curve $\alpha_\Delta(\hbar\omega)$ corresponding to (1) with the experimental one (Fig.), there was established effectivity mass of density of states in additional minimum $E_C^{(2)}$. The values of effective mass m_2^* and oscillator force $f_{1,2}$ for the studied samples depending on composition x of solid solutions are given in Table

With temperature decrease up to $T = 90$K the increase of established energetic gap $\Delta_{1,2}$ is observed and thermal coefficient of its change equals $(4.5 \pm 0.5) \cdot 10^{-4}$ eV/grad coinciding with similar coefficient for forbidden gap [2].

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REFERENCES

1. *E.Sikharulidze, et al.* Soobshchenia Akademii Nauk GSSR. **130**, 1988, 525.
2. *G.A.Sikharulidze, et al.* Fiz.tekh.poluprovodn. **5**, 1971, 2211.
3. *T.Moss.* Opticheskie svoistva poluprovodnikov. M., 1961 (Russian).
4. *G.Sikharulidze, O.Kharatishvili.* Soobschenia Akademii Nauk GSSR. **97**, 1980, 73.
5. *H.Ehrenreich.* J.Phys. Chem. Sol. **12**, 1959, 97.
6. *E.Sikharulidze, et al.* Soobschenia Akademii Nauk GSSR. **57**, 1980, 73.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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PHYSICS

D. Metskhvarishvili, D. Karkashadze, R. Zaridze

Anisotropy Absorbing Magneto-Dielectric Bodies in the Super High Frequency Electromagnetic Fields

Presented by Corr. Member of the Academy T. Sanadze, December 2, 1997

ABSTRACT. **The improved algorithm based on the Method of Auxiliary Sources (MAS) for the problems of scattering and propagation of SHF waves in anisotropy and absorbing magneto-dielectric bodies is presented. It is shown that in comparison with quasi-optical approximation methods the presented method provides the guaranteed precision.**

Key words: anisotropy, absorbtion, diffraction,numerical methods.

Let's consider 2-dimentional problems, when the geometry and vectors of electromagnetic field are dependent only on **x** and **y** coordinates, the body is infinite and regular along **z** axes. In such media the Maxwell's equations of **H** and **E** vectors are symmetrical and thus with the help of simple symbol substitution the analysis of the elliptical polarized waves propagation is reduced to comparatively simple linear polarized waves investigation. In case of E-polarization the single electric field component E_z satisfies the Helmholz anisotropy wave equation [1,2]. With its fundamental solution it is easy to express the E_z component of electromagnetic wave in anisotropy dielectric media induced by linear, parallel to **z** axes, electric source of $\mathbf{j}_z$ density :

$$E_z(\vec{r}-\vec{r}_0)=-\frac{j_z^e}{4}k_0W_0\sqrt{\mu_x\mu_y}H_0^{(1)}\left(k_0\sqrt{\varepsilon_z}\sqrt{\mu_y(x-x_0)^2+\mu_x(y-y_0)^2}\right) \qquad (1)$$

The other two which are not equal to zero components H_x and H_y are obtained from Maxwell's equations system (k_0 is the wave number in free space).

Let us find out the average radiated energy in wave zone during the period caused by electrical source placed in absorbing, anisotropy media. The Pointing vector of the given source (energy passing through the unit of area and average in the duration of period) in the same zone has the following type: $\mathbf{S}=\frac{1}{2}\mathbf{Re}\left[\widetilde{\mathbf{E}}\times\widetilde{\mathbf{H}}^*\right]$, where $\widetilde{\mathbf{E}}, \widetilde{\mathbf{H}}^*$ are the asymptotic values of the field's vectors. In case of E-polarization these vectors have only the following components:

$$\widetilde{E}_z\approx-\frac{j_z^e}{4}kW\sqrt{\frac{2}{\pi k\rho}}e^{-i\left(k\rho-\frac{\pi}{4}\right)};\quad \widetilde{H}_\varphi^*\approx\frac{j_z^e}{4}k\sqrt{\frac{2}{\pi k\rho}}e^{i\left(k\rho-\frac{\pi}{4}\right)};\quad W=W_0\sqrt{\frac{\mu}{\varepsilon}};\quad k=k_0\sqrt{\varepsilon\mu}\,, \qquad (2)$$

W_0 is the wave impedance of free space ($W_0=\sqrt{\frac{\mu_0}{\varepsilon_0}}=120\pi$), ρ the distance in polar

coordinates. Taking into account (2) we will have:

$$S_\rho = \left[\tilde{\vec{E}} \times \tilde{\vec{H}}^*\right]_\rho = \frac{1}{16\pi\rho}|k|\cdot\left|j_z^e\right|^2 \cdot \mathbf{Re}(W)\,. \tag{3}$$

So, the average energy radiated during the period by cylindrical source is equal:

$$P_{radiat} = \int_s S_n ds = \rho \int_0^{2\pi} S_\rho d\varphi = \frac{1}{8}|k|\cdot\left|j_z^e\right|^2 \cdot \mathbf{Re}(W) = \frac{1}{8}k_0 \cdot \left|j_z^e\right| \cdot W_0 \cdot \sqrt{|\varepsilon\|\mu|} \cdot \mathbf{Re}\sqrt{\frac{\mu}{\varepsilon}} \tag{4}$$

The flux from the source is changed if a certain body is placed in its field [3]. The difference value of the source energy flux is simply determined by the scattered field, which the body creates in the point of source location. This energy could be called the source and body interaction energy and is expressed by the following formula: $P_{\text{interact}} = -\frac{1}{2}\mathbf{Re}\left(\vec{j}_e \cdot \vec{E}^*\right)$ [3], where $\vec{E}^*_{sc}(x_0, y_0)$ is the conjugated vector of electric field strength in point $M(x_0, y_0)$ created by the source current $\vec{j}_e$. When the cylindrical body is placed in the field of some cylindrical source, each unit of the source in the average period radiates the energy of:

$$P_{total} = P_{radiat} - P_{interact} = \frac{1}{8}k_0 \cdot \left|j_z^e\right|^2 \cdot W_0 \cdot \sqrt{|\varepsilon\|\mu|} \cdot \mathbf{Re}\sqrt{\frac{\mu}{\varepsilon}} + \frac{1}{2}\mathbf{Re}\left[j_z^e E^*_{sc}(x_0, y_0)\right]. \tag{5}$$

Consider the linear, homogenous, anisotropy cylindrical body of complex **L** cross section (smooth in sense of Lapunov). Suppose the **z**-axes of rectangular coordinates is parallel to the cylinder generation line. The problem is to find out the monochromatic electromagnetic field $E_z(x, y)e^{-i\omega t}$, $H_{x,y}(x, y)e^{-i\omega t}$, which is created in the whole space due to the diffraction of parallel to **z**-axes of $E^i_z(x, y)e^{-i\omega t}$ incident field.

One can show that this problem is reduced to the solution of the system of two wave equations:

$$\begin{aligned} &\frac{\partial^2 E_z(x,y)}{\partial x^2} + \frac{\partial^2 E_z(x,y)}{\partial y^2} + k_0^2 E_z(x,y) = 0, \quad \mathrm{M}(x,y) \in \overline{\mathrm{D}}_0; \\ &\frac{1}{\mu_y}\frac{\partial^2 E_z(x,y)}{\partial x^2} + \frac{1}{\mu_x}\frac{\partial^2 E_z(x,y)}{\partial y^2} + k_0^2 \varepsilon_z E_z(x,y) = 0, \quad \mathrm{M}(x,y) \in \overline{\mathrm{D}}_1; \end{aligned} \tag{6}$$

where $\mathbf{D}_1$ is the area bounded by **L** contour, $\mathbf{D}_0$ -infinite area out of the contour. The solution $E_z(x, y)$ must satisfy the radiation condition and the following boundary conditions on the **L**-contour (the condition of continuity of **E** and **H** tangential components):

$$E^1_z(x,y) = E^0_z(x,y) + E^i_z(x,y), \ \mathrm{M}(x,y) \in \mathrm{L}; \tag{7}$$

$$\frac{1}{\mu_y}\frac{\partial E^1_z(x,y)}{\partial x} n_x + \frac{1}{\mu_x}\frac{\partial E^1_z(x,y)}{\partial y} n_y = \frac{\partial E^0_z(x,y)}{\partial n} + \frac{\partial E^i_z(x,y)}{\partial n}, \ M(x,y) \in L, \tag{8}$$

where **n** is the outside normal to the contour **L** in point $M(x, y)$. $E_z^1(x, y)$ is the limit value of the searched function $\mathbf{E_z(x, y)}$, when the point (x, y) approaches the point $\mathbf{M(x, y)}$ of contour **L** from the $\mathbf{D_1}$ area, and $\mathbf{E_z^0(x, y)}$ is the same one when this point approaches from the $\mathbf{D_0}$ area. We will solve this boundary problem with the help of MAS. For this purpose we choose the auxiliary contours $\mathbf{L_p}$ $(p = 0,1)$ in each media which are separated by the main contour **L**, and these contours $\mathbf{L_p}$ completely surround the **L** contour and have similar form. Also $\mathbf{L_0}$ is in $\mathbf{D_1}$ area and $\mathbf{L_1}$ in $\mathbf{D_0}$ area. We distribute the unlimited, countable set of points $\left\{x_n^p, y_n^p\right\}_{n=1}^{\infty}$ on these contours. After that, we construct two sets of basic functions which are the fundamental solutions of wave equations (6):

$$\left\{G^0(\vec{r}-\vec{r}_n^{\,0})\right\}_{n=1}^{\infty}=\left\{\frac{1}{4}k_0W_0\,H_0^{(1)}\left(k_0\sqrt{(x-x_n^0)^2+(y-y_n^0)^2}\right)\right\}_{n=1}^{\infty}; \tag{9}$$

$$\left\{G^1(\vec{r}-\vec{r}_n^{\,1})\right\}_{n=1}^{\infty}=\left\{\frac{1}{4}k_0W_0\sqrt{\mu_x\mu_y}\,H_0^{(1)}\left(k_0\sqrt{\varepsilon_z}\sqrt{\mu_y(x-x_n^1)^2+\mu_x(y-y_n^1)^2}\right)\right\}_{n=1}^{\infty}, \tag{10}$$

radiating centers of which are in the chosen points of auxiliary sources. $\vec{r}$ and $\vec{r}_n^{\,p}$ are the radius-vectors of observation point and radiating centers, respectively. If the **L** contour is smooth enough and $E_z^1(x,y)$ function is continuous with its derivations on this contour it could be shown [1] that such a contour $\mathbf{L_p}$, $(p = 0,1)$ can be always found and the corresponding sets of functions $\left\{\hat{W}G^p(\vec{r}_L-\vec{r}_n^{\,p})\right\}_{n=1}^{\infty}$ ($\hat{W}$ -the corresponding boundary operator in (7) and (8)) are complete and linearly independent on **L** contour. This also means that the solution of the boundary problem (6)-(8) can always be presented as follows [1]:

$$E_z(x,y)=\sum_{n=1}^{N}a_n^0\,G^0(\vec{r}-\vec{r}_n),\ M(x,y)\in D_0;\quad E_z(x,y)=\sum_{n=1}^{N}a_n^1\,G^1(\vec{r}-\vec{r}_n),\ M(x,y)\in D_1 \tag{11}$$

a_n^0 and a_n^1 are the amplitudes of auxiliary sources placed on the contours $\mathbf{L_0}$ and $\mathbf{L_1}$ respectively. Using (11) in (7) and (8) we will get the rectangular linear equations system:

$$\sum_{n=1}^{N}\left\{a_n^1\,E_z^1(\vec{r}_m-\vec{r}_n^{\,1})-a_n^0\,E_z^0(\vec{r}_m-\vec{r}_n^{\,0})\right\}=E_z^1(x_m,y_m),\ (m=1,2,\ldots,M;\ M\geq N) \tag{12}$$

$$\sum_{n=1}^{N}\left\{a_n^1\left[\frac{1}{\mu_y}\frac{\partial E_z^1(\vec{r}_m-\vec{r}_n^{\,1})}{\partial x}+\frac{1}{\mu_x}\frac{\partial E_z^1(\vec{r}_m-\vec{r}_n^{\,1})}{\partial y}\right]-a_n^0\frac{\partial E_z^0(\vec{r}_m-\vec{r}_n^{\,0})}{\partial n}\right\}=\frac{\partial E_z^1(x_m,y_m)}{\partial n};$$

which pseudo solutions represent the searched values. $\vec{r}_m, \vec{r}_n^{\,1}, \vec{r}_n^{\,0}$ are the radius-vectors of collocation points placed on the main contour and points where auxiliary sources are placed on the external and internal contours respectively.

With this the solution of diffraction problem formally can be said to be completed, but there remains the significant procedure - optimization of solving process. That is a step on which the effective of the algorithm is based on MAS and how effectively the computer resources are used. The optimal parameters in solving the given problem should provide the fixed precision of solution while the dimension of matrix **MxN** in system (12) should be minimal. The most important of the optimized parameters are the form and placement of the auxiliary contours $\mathbf{L}_0$ and $\mathbf{L}_1$. As it is known [1] we should take into account the main singularities of the scattered field in $\mathbf{D}_0$ and $\mathbf{D}_1$ while forming the auxiliary contours. On the other hand calculations show that the auxiliary contours should repeat the form of the main contour, each point of auxiliary contour should be at the equal electrical distance **kd** from the main contour. Also the shorter this distance is the less the dimension **MxN** of matrix is, that provides the desirable precision. But the conditional number of the system decreases while the distance is increased, and so the precision of the solution is decreased. So here one can also make an optimization. Calculations show that the optimal distance is of the order $\mathbf{kd} \approx \mathbf{3} \div \mathbf{5}$, if the auxiliary contours bounds the main singularities of the field. It is obvious that this approach is rather general and in each particular case there is the separate problem to find the global optimum. For example the residual of solution

$$\varepsilon_{E,H}(m) = \sqrt{\frac{\oint_L \left| \sum_{n=1}^{N} \hat{W} \left[a_n^1 \vec{G}^1(\vec{r}_L - \vec{r}_n^1) - a_n^0 \vec{G}^0(\vec{r}_L - \vec{r}_n^0) \right] - \hat{W}\vec{E}^i(\vec{r}_L) \right|^2 dL}{\oint_L \left| \hat{W}\vec{E}^i(\vec{r}_L) \right|^2 dL}}$$

m	ε_E (%)	ε_H (%)
2	25.0000	38.0000
3	0.0120	0.3000
6	0.0003	0.0026
10	0.0001	0.0010

(in sense of $\mathbf{L}_2$ functional space) along the main contour versus the number of collocation points per wavelength. If the order of $\hat{\varepsilon}$, $\hat{\mu}$ tensors elements of the given body is about $5 \div 10$, then the data presented in the Table correctly characterize the convergence of the solution.

For example if the relative perimeter of the body is $P/\lambda \approx 200$ (the perimeter of cylindrical body is equal to **200** wavelength), the tradition is to solve the problem with the quasi optical methods, at the same time the same result given by MAS requires **600x600** dimension system solution, that can be easily performed on the modern computers.

Thus, from data given in the Table, it is seen that the method mentioned above gives the possibility to analyze the problem not only qualitatively, but in most cases to investigate it quantitatively.

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REFERENCES

1. *V. Kupradze*. Uspekhi Mat. Nauk, v.22, 1967, p.59-107 (Russian).
2. *V. Apelzin, R. Zaridze, D. Karkashadze et al.* Mat. of IX all Union Sch. Diffrac. @ Waves Prop. Kazan, 1988 (Russian).
3. *A. Potekhin*. Izluchenie i rasprostranenie electromagnitnikh voln v antitropnikh sredakh. M., 1971 (Russian).

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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PHYSICS

I. Ratishvili, N. Namoradze

Heat Capacity Associated with Hydrogen Ordering in Superstoichiometric Rare-Earth Dihydrides. CeH_{2+c}-like Systems.

Presented by Academician G. Kharadze, December 23, 1997

ABSTRACT. **In the rare-earth superstoichiometric dihydrides RH_{2+c} (R - rare-earth element) the fraction c of hydrogen atoms ($0 < c < 1$) located in the octahedral interstitial sites of the f.c.c. metal lattice undergoes order-disorder and order-order transformations. The possibility of these transitions observation in thermal properties is discussed. The temperature dependences of internal energy and of specific heat are determined in the case of RH_{2+c} systems characterized by the energy parameters ratio $p > 1$.**

Key words: rare-earth dihydrides.

1. In the rare-earth superstoichiometric dihydrides RH_{2+c} (R - rare-earth element) the f.c.c. lattice of N metal atoms contains ideally $2N$ hydrogen atoms located in $2N$ tetrahedral interstitial sites (H_1-atoms) and $N_0 < N$ hydrogen atoms distributed among the N octahedral interstitial sites forming a f.c.c. lattice (H_0-atoms). The concentration of H_0-atoms is defined as $c = N_0/N$. At low temperatures the H_0-atoms are ordered. In the case of compounds LaH_{2+c}, CeH_{2+c}, TbH_{2+c} the superstructure is represented by the distribution function containing two long-range-order (LRO) parameters η_1 and η_2 [1-3]:

$$n(x, y, z) = c + \eta_1 \gamma \exp[i2\pi x] + 2\eta_2 \gamma \cos[\pi(x + 2y)], \quad (1)$$

where $n(x, y, z)$ is the probability that the site with coordinates (x, y, z) is occupied by one of the H_0-atoms; $\gamma = 0.25$ is the normalizing factor. $n(x, y, z)$ takes three different values n_i ($i = 1, 2, 3$) on the set of f.c.c. lattice sites:

$$n_1 = c + \eta_1 \gamma + 2\eta_2 \gamma; \; n_2 = c + \eta_1 \gamma - 2\eta_2 \gamma; \; n_3 = c - \eta_1 \gamma. \quad (2)$$

n_1, n_2 and n_3 denote the sites occupation numbers. They satisfy the conditions:

$$0 \le n_i \le 1, \; (i = 1, 2, 3) \quad (3)$$

The free-energy function of the subsystem of H_0-atoms can be written as [4,1]

$$F(\eta_1, \eta_2) = E(\eta_1, \eta_2) - TS(\eta_1, \eta_2), \quad (4a)$$

$$E(\eta_1, \eta_2) = 0.5 N k_B [V_0 c^2 + V_1(\eta_1 \gamma)^2 + 2V_2(\eta_2 \gamma)^2], \quad (4b)$$

$$S(\eta_1, \eta_2) = -N k_B \Sigma_i \nu_i \{n_i \ln n_i + (1 - n_i) \ln(1 - n_i)\}. \quad (4c)$$

Here V_0, V_1 and V_2 are the energy constants characterizing the ordered system; they are given in temperature units (see [1]); ν_i ($i = 1, 2, 3$) are the fractions of lattice sites, where $n(x, y, z) = n_1$, n_2 or n_3, respectively; $\nu_1 = \nu_2 = 0.25$; $\nu_3 = 0.5$.

The expression for the free energy function (4) is written within the mean-field approximation of the static concentration waves theory [4].

The coordinates of the free-energy extrema fulfill equations:

$$\partial F(\eta_1, \eta_2)/\partial \eta_1 = 0, \; \partial F(\eta_1, \eta_2)/\partial \eta_2 = 0. \quad (5)$$

The type of extremum (minimum, maximum, or saddle point) is determined by the sign of one of the second derivatives and that of the determinant $\Delta(\eta_1, \eta_2)$,

$$\Delta(\eta_1, \eta_2) = (\partial^2 F(\eta_1, \eta_2)/\partial \eta_1^2)\,(\partial^2 F(\eta_1, \eta_2)/\partial \eta_2^2) - [\partial^2 F(\eta_1, \eta_2)/\partial \eta_1 \partial \eta_2]^2. \quad (6)$$

($\Delta > 0$ corresponds to a minimum or maximum, and $\Delta < 0$ - to a saddle point).

The equilibrium values $\bar{\eta}_1(T)$ and $\bar{\eta}_2(T)$ are determined as coordinates of the absolute minimum of the free-energy function (4) in the space of variables (η_1, η_2). Introducing $\bar{\eta}_1(T)$ and $\bar{\eta}_2(T)$ in (4b), we obtain the temperature dependence of the equilibrium internal energy $E(T)$ of the ordering system. Temperature derivative of $E(T)$ dependence gives the heat capacity associated with the ordering process

$$C(T) = \partial E(T)/\partial T. \quad (7)$$

2. Solutions of equations (5) are obtained by numerical calculations. These solutions depend significantly on the ratio of energy constants

$$p \equiv V_2 / V_1 \quad (8)$$

and require different programs for the cases $p < 1$ and $p > 1$.

In [5] we discussed the heat capacity of systems characterized by the energy parameters ratio $p < 1$. (We called these systems "LaH_{2+c}-like systems", as $p(LaH_{2+c}) = 0.7743 < 1$ [3]).

In the present investigation we tend to apply the general scheme used in [5] to the systems with $p > 1$. We call them the "CeH_{2+c}-like systems", as it was estimated [2] that $p(CeH_{2+c}) = 1.25 > 1$.

The corresponding calculations were performed for some hypothetical model compounds with concentration $c = 0.35$ and different $p > 1$, on assuming:

a) $V_0 = 0$, $V_1 = -1220$ K = const., $V_2 = p\,V_1$;

b) c = const. in the temperature range under consideration (60 K < T < 450 K);

c) $E(T)$ and $C(T)$ are presented in the units (J/mol) and (J /mol K), respectively. ("mol" denotes the gramm-molecule of RH_{2+c} compound and not of the interstitial H_0-atoms only.)

The obtained numerical results are shown in Figs.1-3.

3. In Fig.1 there are shown $E(T)$ dependences for p = 1.1, 1.2, 1.25 and 1.4 . The discontinuities contained in the internal energy curves indicate the transition heats associated with the discontinuous order-disorder and order-order transformations. The heat capacities are determined by derivatives of these $E(T)$ curves. The high-temperature parts of $C(T)$ dependences are given in Fig.2, while the low-temperature parts - in Fig.3.

Additionally we give some obtained numerical results concerning the phase transitions in the systems under consideration: transition temperatures T_{tr} (K), transformation heats ΔE_{tr} (J/mol) and heat capacity anomalies ΔC_{tr} (J/mol K).

p = 1.10	T_{tr1} = 308.5	ΔE_{tr1} = 32.33	ΔC_{tr1} = 8.77
	T_{tr2} = 88.5	ΔE_{tr2} = 20.25	ΔC_{tr2} = 0.113
p = 1.20	T_{tr1} = 333	ΔE_{tr1} = 15.16	ΔC_{tr1} = 17.49
p = 1.25	T_{tr1} = 347	ΔE_{tr1} = 5.58	ΔC_{tr1} = 37.70
p = 1.40	T_{tr1} = 388.6	ΔE_{tr1} = 0	ΔC_{tr1} = 6.07

4. One remarks at once that the $C(T)$ curves alone are not sufficient to determine the type of the phase transition, as the $C(T)$-dependences are quite similar for both types of transitions: continuous and discontinuous. Note that in Figs.2 and 3 only the derivatives of the energy curves, without taking into account the transformation heats ΔE_{tr} are shown.

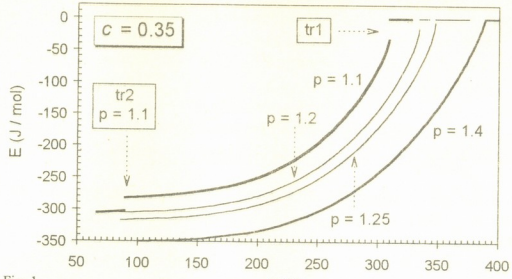

Fig. 1

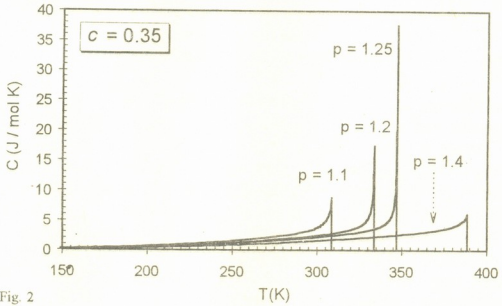

Fig. 2

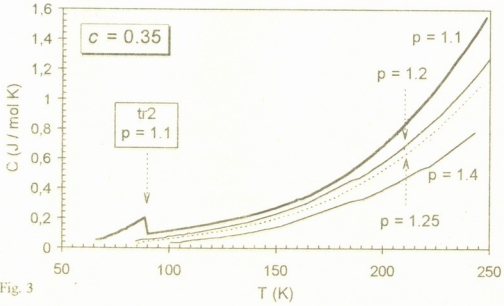

Fig. 3

An interesting result of our calculations is the fact that the amplitudes of the heat capacity anomalies in the order-disorder and order-order transition points can differ by the orders of magnitude, while the transition heats of these transformations remain of the same order (compare the values of ΔC_{tr1}, ΔE_{tr1} and ΔC_{tr2}, ΔE_{tr2} in the case of $p = 1.1$). The latter condition allows us to conclude that although $\Delta C_{tr2} << \Delta C_{tr1}$, the order-order transition can be observed in thermal properties, because the transition heat ΔE_{tr2} will be automatically included in the difference $[E(T + \Delta T) - E(T)]$ of the sample heat capacity, measured at $T = T_{tr2}$.

It was shown previously [6] that in the case of $p>1$, within the range $0< c < 0.5$ the ordering is a one-step process, containing the order-disorder transition point, when $c < c_1(p)$, and it transforms into a two-step process containing an additional order-order transformation, when $c > c_1(p)$. The critical $c_1(p)$ values are given by the expression: $c_1(p) = 0.75-(1/2p)$ [6]. In our cases we have: $c_1(1.1) = 0.295$, $c_1(1.2) = 0.333$, $c_1(1.25) = 0.35$ and $c_1(1.4) = 0.393$. As we can see, in our case of $c = 0.35$ we should have: a one-step process for $p = 1.4$ and $p = 1.25$, and a two-step process for $p = 1.2$ and $p = 1.1$. In Figs.1 and 3 the expected order-order transition points are not indicated on the curves corresponding to $p = 1.2$. This is caused by the fact that $T_{tr2}(p = 1.2)$ is outside of the considered temperature range.

Some words about the correlations between the concentration c, the energy parameter p and the amplitude of the heat-capacity anomaly in the order-disorder transition point T_{tr1}. We have shown [7], that in the case of systems with $p > 1$, the order-disorder transition is discontinuous at concentrations $c < c_0(p)$, while for $c_0(p) < c < 0.5$ it is continuous. The critical values $c_0(p)$ are determined by the expression [7]: $c_0(p) = 0.5\ \{1-[(p-1)/3]^{1/2}\}$. Thus, we have: $c_0(1.1) = 0.409$, $c_0(1.2) = 0.371$, $c_0(1.25) = 0.356$ and $c_0(1.4) = 0.317$. As we see, the maximum amplitude $\Delta C_{tr1}(p = 1.25)$ corresponds to the case when $c \approx c_0(p)$.

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REFERENCES

1. *I.G.Ratishvili, P.Vajda.* Phys. Rev. B 47,1993, 14 062.
2. *I.G.Ratishvili, P.Vajda, A.Boukraa, N.Z.Namoradze.* Phys. Rev. B 49,1994, 15 461.
3. *I.G.Ratishvili, P.Vajda.* Phys. Rev. B 53,1996, 581.
4. *A.G.Khachaturyan.* Theory of Structural Transformations in Solids. Wiley, New York, 1983.
5. *I.G.Ratishvili, P.Vajda, N.Z.Namoradze.* J.Phys.Chem.Solids, 58, 1997, 59.
6. *I.G.Ratishvili, P.Vajda, N.Z.Namoradze.* J. Alloys and Compounds, 231, 1995, 115.
7. *I.G.Ratishvili.* Bull.Georg. Acad. Sci. **155**, 1997, 196.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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PHYSICS

I. Lomidze, D. Karkashadze, J. Javakhishvili, G. Kervalishvili, G. Khutsishvili

The Necessity of the Account of Static Fields in Non-stationary Interference of Electromagnetic Packages

Presented by Corr. Member of the Academy A.Khelashvili, December 31, 1997

ABSTRACT. **The necessity of the account of static fields in nonstationary interference of electromagnetic packages is shown. Possible gears of energy transportation are discussed.**

Key words: non-stationary interference, tachyon, energy flow, movement of interference zone.

In [1] there was considered a non-stationary interference of electromagnetic (EM) impulses, having δ-type distribution of intensity. However, there are difficulties with the indication of the sources, supplying the interference surplus of energy in a zone of intersection of impulses. This zone, being a "volumetric" updating of super-lightbeam, represents EM model of a tachyon and has a number of specific characteristics that are analyzed in details in [2]. Differences of such object from "true" tachyon are also discussed there. It is essential that δ-type model of impulses used in [1] and [2] does not coinside with the boundary conditions of a system of Maxwell equations for EM fields in every space-time points. Therefore conclusions made on a basis of such a model are not quite convincing as some effects may arise on surfaces of discontinuity that are rather difficult to analyze [3].

In the present paper a study of non-stationary interference of EM impulses spread in vacuum is continued. We use the model of impulses consistent with all boundary conditions. Following [1], let us consider two identical elementary dipoles located in the points $(0, 0, l)$ and $(0, 0, -l)$ and oriented along the axis $0Z$. Let at the moment of the time $t = 0$ both dipoles simultaneously (in given inertial coordinate frame) begin to radiate and radiate then continuously during a time $\Delta t << 2l/c$ (c stands for speed of light in vacuum).

Let the origin of a spherical coordinate frame coinside with the centre of dipole, the axis $0Z$ being oriented along the dipole moment. Let $t^* = t - r/c$ be a retarded time and let us denote

$$E_0 = ce/(4\pi l^2),\ x = r/l,\ \tau = ct/l = t/t_0,\ \tau^* = t^*/t_0 = \tau - x,$$

$$\Delta\tau = c\Delta t/l = \Delta t/t_0,\ f(t^*) = p(t^*)/(el)$$

(e is an elementary charge and $p(t^*) = p_1(t^*) = p_2(t^*)$ is module of dipole moment). Let us consider a configuration of EM fields at the moment $t \geq t_0 = l/c$, i.e. $\tau \geq 1$. The symmetry of considered problem requires that in vacuum the components E_φ, H_r, H_Θ of electrical $\vec{E}$ and magnetic $\vec{H}$ fields on the axis of chosen coordinate frame should be equal to zero, i.e.

$E_\varphi = H_r = H_\Theta = 0$, and nonzero components of the fields have the following form (see e.g., [4] and [1]):

$$E_r(t) = E_0 \cdot \widetilde{E}_r(\tau), \qquad \widetilde{E}_r(\tau) = \frac{2}{x}\left[\frac{f'(\tau^*)}{x} + \frac{f(\tau^*)}{x^2}\right]\cos\Theta,$$

$$E_\Theta(t) = E_0 \cdot \widetilde{E}_\Theta(\tau), \qquad \widetilde{E}_\Theta(\tau) = \frac{1}{x}\left[f''(\tau^*) + \frac{f'(\tau^*)}{x} + \frac{f(\tau^*)}{x^2}\right]\sin\Theta, \qquad (1)$$

$$H_\varphi(t) = E_0 \cdot \widetilde{H}_\varphi(\tau), \qquad \widetilde{H}_\varphi(\tau) = \frac{1}{x}\left[f''(\tau^*) + \frac{f'(\tau^*)}{x}\right]\sin\Theta,$$

where Θ is an angle between the axis $0Z$ and radius-vector, drown from dipole location point in point of observation, dash over $f(\tau^*)$ means derivative with respect to dimensionless time τ.

Let us choose dependence of dimensionless dipole moment $f(\tau^*)$ on retarded time τ^* as

$$f(\tau^*) = \begin{cases} 0, & \tau^* < 0, \\ \tau^{*5}\left(14(\Delta\tau)^3 - 28(\Delta\tau)^2\tau + 20(\Delta\tau)\tau^{*2} - 5\tau^{*3}\right), & 0 \le \tau^* < \Delta\tau, \\ \left(2\tau^* - \Delta\tau\right)(\Delta\tau)^7, & \tau^* \ge \Delta\tau. \end{cases} \qquad (2)$$

Actually by this choice the law of dipole radiation is given. The law of radiation (2) provides a continuity of field functions $\widetilde{E}_r(\tau)$, $\widetilde{E}_\Theta(\tau)$ and $\widetilde{H}_\varphi(\tau)$ and their first and second derivatives.

Note that according to (2) one gets

$$f''(\tau^*) = 280\,\tau^{*3}(\Delta\tau - \tau^*)^3, \quad \tau \in [0, \Delta\tau],$$

$$f''(\tau^*) = 0, \qquad \tau \notin [0, \Delta\tau].$$

Then from the specified formulae follows that the fields of radiation, decreasing proportionally to $1/x$, are intersected in the region of crossing two spherical layers with thickness $\Delta x = \Delta\tau$ and with external radius $r^* = 1/x^*$ and with centres in points of the dipoles location (thus $r^{*2}(t) = (ct)^2 - l^2$ and $x^{*2}(\tau) = \tau^2 - 1$). Due to linearity of Maxwell equations in the intersection area for density of energy W one obtains:

$$W = W_1 + W_2 + \delta W. \qquad (3)$$

In (3) $W_i\,(i = 1, 2)$ stands for the partial contribution of each field in total W and the member δW has arisen as a result of interference:

$$W_i = \frac{1}{8\pi}(\vec{E}_i^2 + \vec{H}_i^2), \quad \delta W = \frac{1}{4\pi}(\vec{E}_1\vec{E}_2 + \vec{H}_1\vec{H}_2). \qquad (4)$$

By consideration moments of a time τ' and τ'' which perform a partition of the whole time interval $\tau \in [1 + \Delta\tau, 2]$, (i.e. $t \in [t_0 + \Delta t, 2t_0]$) into three subintervals:

$$1 + \Delta\tau \le \tau \le \tau', \ \tau' \le \tau \le \tau'', \ \tau'' \le \tau < 2,$$

where

$$\tau' = \frac{\sqrt{(\Delta\tau)^2 + 32} + \Delta\tau}{4} \text{ and } \tau'' = \tau' + \frac{\Delta\tau}{2},$$

it is possible to show that in the area of intersection of fields of radiation $r \in [r^* - \Delta r, r^*]$, where $\Delta r = |\Delta\tau$, and in all moment of time $t \in [t_0 + \Delta t, 2t_0]$ condition $\delta W(r, t) > 0$ is valid.

In Figs.1 and 2 the results of calculations in the plane $X0Z$ of the quantities $\delta W(\tau = 1.3)$ and $\delta W(\tau = 1.7)$ are shown. It is easy to see that the kinematics of longitudinal and cross sizes of the area of intersection of EM fields allows "tachyonic interpretation" [2]. It should be emphasized that in any moment of a time the law of conservation of EM energy in the integral form is faultlessly valid. Our calculation shows that

$$\int \delta W(r^*, t)\, dV = 0$$

is valid up to calculation error. Here integration is done on all over the area of the space, engaged by EM field. In this connection it should be emphasized that areas with negative δW, existence of which is necessary to guarantee the energy balance, arise because of interference of fields of radiation with "electrostatic" (in our case, the dipole, decreasing on large distances as $1/r^3$) and "magnitostatic" (in our case the field behaves on large distances as $1/r^2$). The attempt to analyse energetic processes in the differential form, i.e. that is based on the concepts of energy density and density of a flow of energy (Pointing vector) results some difficulties in interpretation of a gear of moving in the space interference maxima and minima. In particular, it is impossible to agree that the real transportation of surplus of energy to a zone of interference maximum has taken place by means of

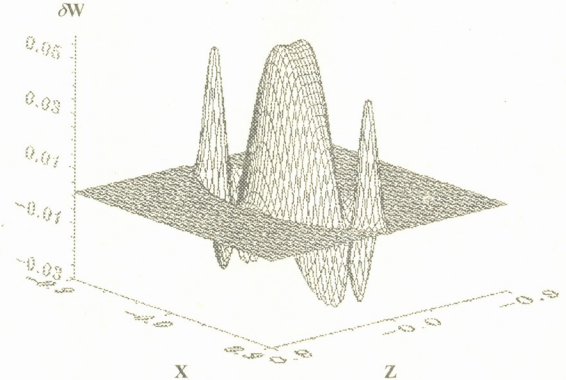

Fig. 1

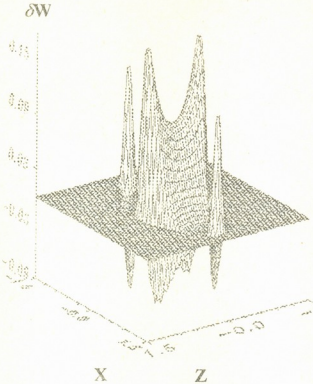

Fig. 2

certain gear, working in superlight mode (e.g., with a flow of "true" tachyons). One has to conclude that at nonstationary interference of packages the movement of interference zone, containing excess energy, can not be explained by flows from sources connected with radiating charge [5]. Our calculations show that the advancing Makh cone that guarantees transportation of energy to "tachyon" considered in [2] in our case does not contain necessary quantity of energy. However the space-time area causally connected with the impulses intersection area always contains sufficient quantity of energy to provide the existence of interference maximum.

It seems nontrivial that the necessary flow of energy arises only when we take into account electrostatic and "magnitostatic" parts of fields despite that intensities of these fields rather quickly decrease with respect to distance.

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REFERENCES

1. *J.I.Javakhishvili, I.R.Lomidze, G.I.Mamisashvili.* Bull. Georg. Acad. Sci. **148,** 3, 1993, 28.
2. *M.I.Faingold.* Izvestia vuzov. Radiofizika. **XXII**, 5,1979, 531 (Russian).
3. *J.D.Jackson.* Classical Electrodynamics. New-York - London. 1962.
4. *G.Franceschetti, Ch.H.Papas.* IEEE, Trans. on Anten. and Propagation, **AP-22**, 5, 1974, 651.
5. *J.I. Javakhishvili, I.R. Lomidze, D.D. Karkashadze.* XXVth General Assembly of URSI. Abstracts, Lille, France, 1996, 84.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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GEOPHYSICS

E. Sakvarelidze, N. Mamulia

Determination of Rock Heat Conduction Based on the Regular Heat Regime Method in Wide Temperature Range

Presented by Academician B. Balavadze, October 20, 1997

ABSTRACT. **This paper represents experimentally investigated heat conduction of some rocks on the territory of Georgia, in 300-900K temperature interval. Characteristic constants of these rocks are determined experimentally. The short description of the experimental device is given.**

Key words: heat conduction coefficients, rocks.

Investigation of the dependence of rock heat conduction on temperature is of great interest in view of geophysical (in particular, geothermal) tasks solution. The reliable method for estimation of temperature in the crust is the temperature calculation based on the solution of heat conduction equation. Regarding steady heat models of the earth's crust, it is necessary to know the temperature dependence of rocks heat conduction coefficients.

This dependence can be represented in the following way [1]

$$\lambda = \frac{1}{\rho_0 + \alpha T}$$

where ρ_0 and λ are rock characteristics adopted by experiment, T is a temperature.

This paper represents the results of the experimental investigation of heat conduction of some rocks on the territory of Georgia, which has been carried out in the high temperature range of 300-900K. Similar works are described in [1-6].

The experimental device has been constructed in Tbilisi I. Javakhishvili State University and is analogous to the device of Moscow State University [6]. The investigation method is based on the third type regular heat requirement. The method presented here has some advantages in comparison with the method used in [2-4]: the small sizes of samples reduce considerably the duration of the experiment and rule out necessity of using core only.

The scheme of device is given in Fig. 1. The main tangles of the divice are: measuring cell with sample, the pulse oscillator and metering device. The sample is a flat - parallel plate. Ni-Cr alloy inertialess flat heater 2 emits periodical heat flow at one of the sample surfaces and it is squeezed between two identical samples. The pulse oscillator 3 transmits power of heater as impulse, and variable heat flow initiates temperature waves on the another surface. Their recording is carried out by КСП 4 self-recorder 4 by means of chromium-nickel alloy - alumel thermocouple 5. The cell 6 with sample is placed in thermostat 7 the temperature of which varies in 300-900K range. After treating the curves

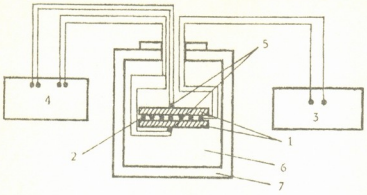

Fig. 1. Scheme of experimental device

of temperature waves induced on the surface of sample, the heat conduction coefficient λ is calculated, relative error of its determination appears to be within 10%.

14 rock samples from Akhalkalaki, Bolnisi and Madneuli regions have been investigated. Among them are: granites, basalts and sediment rocks. For all samples reduction of λ with temperature rise is observed. The obtained results can be explained by the mechanism of the crystal lattice heat conduction, according to which the temperature rise causes increase of the number phonon-phonon collisions, and therefore, heat conduction is reduced.

As it was expected, the $\lambda(T)$ dependence for granites is more explicit than for basalts. This fact can be explained by the larger fracture of amorphic phase in basalts in comparison with granites.

$\lambda(T)$ typical curves are given in Fig. 2. In the Table there are ρ_0 and λ constants calculated for all samples. For each sample ρ_{01} and λ_1 denote values of constants above some specific temperature.

Table

Name of rock, the place of sampling	Density	α $\frac{\text{cm}\cdot\text{sec}}{\text{cal}}$	α_1	ρ_0 $\frac{\text{cm}\cdot\text{sec}\cdot\text{K}}{\text{cal}}$	ρ_{01}
Organogenic limestone. Madneuli	2.67	0.450		117	
Sandstone. Madneuli	2.55	0.720	0.215 T>475K	90	185T>475K
Fine-grained sandstone. Bolnisi	2.53	0.733	0.22T>490K	93	191T>490K
Organogenic limestone. Madneuli	2.73	0.471		115	
Granite. Akhalkalaki	2.60	0.36	0.138T>400K	95	121T>400K
Granite. Akhalkalaki	2.60	0.40	0.137T>370K	90	120T>370K
Granite. Akhalkalaki	2.65	0.475	0.142T>357K	78	115T>357K
Granite. Akhalkalaki	2.63	0.41		80	
Granite. Akhalkalaki	2.55	0.321	0.12T>340K	103	142T>340K
Basalt. Akhalkalaki	2.92	0.091		155	
Basalt. Akhalkalaki	2.77	0.12		154	
Basalt. Akhalkalaki	2.80	0.123		151	
Basalt. Akhalkalaki	2.70	0.098		176	
Basalt. Akhalkalaki	2.65	0.11		178	

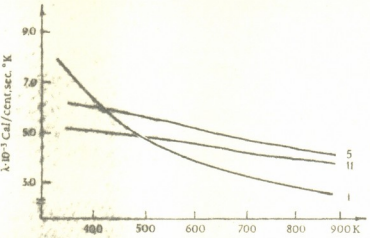

Fig. 2. $\lambda(T)$ typical curves. 1, 5 and II correspond to sample numbers given in the Table

In conclusion we would like to mention, that the obtained results are in a good agreement with the results given in other papers. The presented method enables us to obtain reliable results for experimental investigation of the rock heat conduction.

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REFERENCES

1. *E. A. Sakvarelidze.* Bull. Georg. Acad. Sci. **57**, 3 1970 (Russian).
2. *Idem.* Bull. Georg. Acad. Sci. **51**, 1, 1968 (Russian).
3. *E. A. Sakvarelidze, R. A. Gonstridze, Z. W. Chanishvili.* Bull. Georg. Acad. Sci. **80**, 3, 1975 (Russian).
4. *E. A. Luhimova, E. A. Sakvarelidze.* Doklady AN SSSR, **143**, 4, 1970 (Russian).
5. *G. P. Trach, R. P. Jurchik.* Izvestiya AN SSSR. Ser. Fizika zemli, 5, 1972 (Russian).
6. *V. G. Popov, G. N. Petrunin, A. G. Nesterov.* Ustanovka dlya izmereniya temperaturoprovodnosti i teploemkosti gornykh porod i mineralov v intervale temperatur 300-1000K. Moskva, 1981 (Russian).

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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GEOPHYSICS

G. Erkomaishvili, I. Shatberashvili, M. Tsitskishvili

Atmosphere Self-Rectification Peculiarities from Aerosols

Presented by Academician B. Balavadze, April 30, 1998

ABSTRACT. **The 2-equations geophysical model of aerosols washing from the undercloud layer based on 2 simple equations of the washing was considered. The experimental data of admixture concentration in sediments were obtained in 2 points, Tbilisi and Kojori. The constants of the washing, based on data, given as a result of the monthly work during 3 years were defined. The unique experimental data give us the possibility to get the geophysical characteristics of the process of the undercloud washing.**

Key words: aerosol, sedimentation, coagulation.

Various kinds of admixtures (solid, liquid or gaseous) getting in atmosphere stay there for definite time. It depends on many processes: the turbulent calculation, sedimentation or coagulation with particles of clouds, their washing by atmospheric sediments. During the study of geo-ecological aspects of the atmosphere soiling, processes of the admixtures sedimentation from the atmosphere are divided conventionally into two groups: dry "sedimentation" and "washing" by atmospheric sediments ("dry" and "wet" sedimentation).The conventionality of such division is clear, if we go deep into physical and chemical mechanisms of processes, which go on in the atmosphere. Simple analysis shows us, that gravity and elementary forces as well as the turbulence, moisture and density of gas (in this case different layers of the atmosphere) always take part in each process (in the case of loaded particles). In spite of the conventionality of such division, it gives us the possibility to reveal regional geophysical peculiarities in processes of the same admixture (or pollution's) sedimentation from the atmosphere. It's a well-known fact, that during the sedimentation of aerosolic particles from the atmosphere, there are much more "wet" sediments, than "dry" ones, but it's difficult to make the correct numerical estimation, in spite of huge number of experimental and theoretical data. It is grounded in [1- 5].

According to formula of P. N. Tverskoi, sedimentation velocity of the aerosolic particles is proportional to the square of its radius and equals to

$$V = 1.26 \cdot 10 \cdot r \text{ cm/sec.}$$

$$100\text{m}/24 \text{ hours} = 0.12 \text{ cm/sec} \qquad (1)$$

From this equation the quantity of the particle is $r = 0.3 \cdot 10^{-3}$cm. It completely coincides to real estimation [6].The differential function of non-natural radioactivity can be written simply:

$$\varphi(r) = b^2 r \cdot \exp(-br), \qquad (2)$$

where r is the radius of aerosolic particles, b is the constant ($b = 3.7 \cdot 10^4$ cm^{-1}) [3-5].

The analysis of the equation (2) shows, that $\varphi(r)$ reaches maximum, when $r \approx 0.3$ mkm.

We found, that $\varphi(r)$ quantities of velocities of lower troposphere rectification, which we got in Transcaucasia, vary from 160 to 3300 m/24 hours. During the whole period of observation average quantities of velocities for different points of Transcaucasia have small number of sparse 800 - 1140 m/24 hours $(0.24 - 0.38 \cdot 10^5$ m/month).

Minimum values of velocities of lower troposphere rectification could be compared with dry sedimentation velocities of suspension on average aerosolic particles by specter sizes.

In [7] the formula for calculation the velocity of dry sedimentation is given

$$V = 0.2d^{0.9}, \tag{3}$$

where V is the velocity of dry sedimentation (cm/sec), d - Stock's diameter (mkm). (It was meant, that density of the particle is 1 g/cm^3). The equality (3) was used in calculations for value of dry sedimentation velocities and we got 0.2 - 0.4cm (173 - 346 m/24 hours) This coincides to the literature data, which we have got.

For the estimation of wet self-rectification velocities, we have worked out unique experimental data of RaD lasting systematic calculations (Radium D - $_{82}Pb^{210}$ - natural radioactive isotope of the lead, member of uranium radioactive family's, decomposition in sediments. This radioisotope is used widely in special biophysical study. This was conditioned by its simple registration (monochromatic line of γ radiation 470 kev) and the duration of half-decomposition period, $T_{1/2}$ = 22.2 year. These calculations were done in 1966 - 1968 in the Institute of Geophysics of Georgia by Sh. Chkhenkely, T. Khunchua and T. Golub (Table 1). In the Table, the first geoclimatic information between two points is given, where the disparity of vertical altitudes is ΔH and which are close to each other in horizontal coordinates (the assumption is, that in both points precipitations are formed in the same cloud system). The concentration of RaD in precipitations (annual monthly data) is calculated.

It was experimentally measured concetration of radon (C_1, C_2) and quantities of precipitatious (C_1, C_2), in Delisi and Kojori (t_1, t_2) for months.

According to K. Makhanko and G. Dmitreva [2,5] velocity of washing is:

$$V = \frac{C_x I}{Q} \tag{4}$$

C - concentration in sediments, I - intensity, Q - pre-ground concentration.

After a number of mathematic transformations for the velocity of washing, we got:

$$V = \frac{C_{1x} I_1 \ln \dfrac{C_{1x} I_1}{C_{2x} I_2} (1 + \dfrac{C_{2x} I_2}{C_{1x} I_1})}{2(|C_2 - C_1|)(\dfrac{I_1 + I_2}{2})}. \tag{5}$$

We used this experimental results and estimated these quantities (Table 1). Given results coincide with well-known estimation in literature [5-9]. Experimental results show us the following.

Table 1

year/month		Delisi					Kojori
		I_1	I_2	C_1/C_2	C_2/C_1	$\propto$	$\propto_{av} \times 10^{-5}$ sec^{-1}
1966	1	0.310	4.029	2.186	0.458	0.210	1 - 12.477
	2	0.024	0.578	0.479	2.089	1.320	2- 3.454
	3	0.286	1.393	2.533	0.395	0.840	3- 7.965
	4	0.772	6.163	0.660	1.515	0.077	
	5	1.545	1.195	0.423	2.364	0.099	
	6	0.981	3.641	1.744	0.574	0.209	
	7	2.638	4.767	1.757	0.569	0.136	
	8	0.542	4.380	1.056	0.947	0.029	
	9	0.656	11.267	1.433	0.698	0.034	
	10	0.350	3.771	2.264	0.442	0.239	
	11	0.686	6.967	3.147	0.318	0.183	
	12	0.331	1.550	1.077	0.928	0.061	
1967	1	0.307	2.433	3.918	0.255	0.642	
	2	0.203	1.633	1.725	0.580	0.381	1- 8.690
	3	0.404	3.500	1.058	0.945	0.018	2- 5.097
	4	0.541	4.874	0.799	1.252	0.052	
	5	0.912	5.786	3.380	0.296	0.250	
	6	1.132	3.808	3.971	0.252	0.515	
	7	1.101	5.782	1.889	0.529	0.136	
	8	0.607	2.786	1.436	0.696	0.166	
	9	1.039	6.117	1.133	0.882	0.025	
	10	1.871	4.660	1.025	0.967	0.009	
	11	1.499	6.243	0.926	1.080	0.013	
	12	0.164	2.122	4.379	0.228	0.754	
1968	1	0.180	3.500	10.510	0.095	0.708	1- 8.731
	2	0.222	2.275	2.093	0.478	0.360	2- 3.806
	3	0.248	5.657	1.644	0.608	0.092	3- 6.268
	4	0.607	6.993	0.663	1.508	0.064	
	5	0.891	4.724	0.862	1.160	0.039	
	6	0.982	9.413	0.788	1.269	0.028	
	7	1.296	4.501	1.725	0.580	0.166	
	8	1.968	6.110	0.829	1.207	0.045	
	9	1.568	8.664	7.538	0.133	0.285	
	10	0.571	3.817	0.431	2.319	0.259	
	11	0.202	2.333	3.203	0.312	0.546	
	12	0.444	6.465	2.011	0.497	0.116	

1 - of the cold season
2 - of the warm season
3 - average annual

The whole region is characterized by:

Annual washing: cold season $9.966 \cdot 10^{-5}$ sec^{-1}

warm season $4.119 \cdot 10^{-5}$ sec^{-1}

average annual $7.029 \cdot 10^{-5}$ sec^{-1}.

Processes of atmosphere self-rectification are much more intensive; our estimation $=7 \cdot 10^{-5}/sec^{-1}$ is much higher than the results, which are given by other researchers.

It's noticeable, that estimations, given for each season, warm and cold, twofold differ from each other and show correctness of the existing mechanisms of atmosphere self-rectification [1-9].

Given experimental estimations give us the possibility to use scientific conditioned planning measures for atmosphere protection.

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REFERENCES

1. Trudy IV mezhdunarodnogo simpoziuma po yadram kondencatsii (1961 g.) Pod red. E.C. Selezniovoi. L., 1964, 274 (Russian).
2. Sb. dokladov konferentsyi v Palange (1966g.) Vilnius, 1968, 351 (Russian).
3. *X. Junge*. Khimicheskii sostav i radioaktivnost atmosfery. M., 1965, 423 (Russian).
4. *B.I. Sturo*. Samoochishchenie atmosfery ot radioaktivnykh zagryaznenii. 1986, 286 (Russian).
5. Issledovanie primesei v atmosfere. Vilnius, 1995, 120 (Russian).
6. *M.S. Tsitskishvili*. In: Trudy mezhdunarodnogo simpoziuma (1975 g.) L., 1975 (Russian).
7. *N.A. Esmen, M. Gorn*. Residence time of particles in urban air. Atmosp. Envir., 5, 1971, 8.
8. *I.I. Burtsev, S.G. Malakhov*. Vimyvanie osadkami produktov deleniya iz podoblachnogo sloya atmosfery. Izv. AN SSSR, fizika atmosfery i okeana. T.4, vyp. 3, 1968 (Russian).
9. *A.S. Avramenko*. Avtoreferat kand. diss. IEM GUGMC. Obninsk, 1972, 149 (Russian).

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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I. Shatirishvili, Sh. Shatirishvili, N. Chkhartishvili

Determination of "Aromatic Number" by Capillary Chromatography in Some Georgian Wines

Presented by Academician T. Andronikashvili, November 13, 1998

ABSTRACT. **Using capillary chromatography individual composition of vapour phase has been studied for some Georgian wines. The "aromatic number" of these beverages has been determined.**

Key words: beverage, aromatic, wine.

Recent rapid development of analytical and instrumental methods and among them in the first place, development of chromatography has found wide use in the identification of a great number of individual substances in alcoholic beverages [1-3].

The quality of alcoholic beverages predominantly brandy and wine to a certain extent is determined by their flavour, which greatly depends on their volatile component content. The evaluation of English port-wine flavour made it possible to define 5 areas of potentially important components. Dihydrofuranon predominates in one of the areas and amber acid in the second one.

For the analysis of alcoholic beverages it is particularly effective to use capillary chromatography, which makes it possible to receive 400 peak clearly defined chromatograms within the period of 2-3 hours [4]. Such chromatograms related to the compositions possessing peculiar bouquet are called aromatograms.

For evaluating spirits some reseachers have itroduced the concept of "aromatic number", which represents the ratio of the given substance concentration to its critical value perceptible for a human being [5].

Besides, in their calculations the authors use the data on the contents of the liquid phase which is not entirely correct in all respects.

In our case we were studying the content of wine vapour phase as it is the vapour phase which determines the flavour of the product.

While studying aroma-generating substances in Georgian wines we used their helium extraction with subsequent holding on tenax sorbent, thermal desorption in cooling trap and transferring to chromatographic column.

The experiment on determining wine vapour phase content was made by means of a cryogen collector and a MEGA chromatograph model 520 "KARLO ERBA" equipped with automatic vapour sample introducing device model 250. The volume of the sample was $5cm^3$. Glass capillary column of 50 m long and 0.32 mm diameter with 0.4 mkm thick polyethyleneglycol 400 immobile phase was used. Consumption of gas carrier helium constituted 2.5 ml/min; the temperature of injector was 200^0C and that of detector was 250^0C.

In the process of conducting chromatography the following regime of temperature programming was used : 15^0C - 6^0C/min - 50^0C - 3^0C/min - 90^0C. The chromatograms represent curves for 11 components containing in vapour phases of Georgian wines *Hereti*, *Mukusani*, *Tibaani* and *Sameba* (Fig.1.)

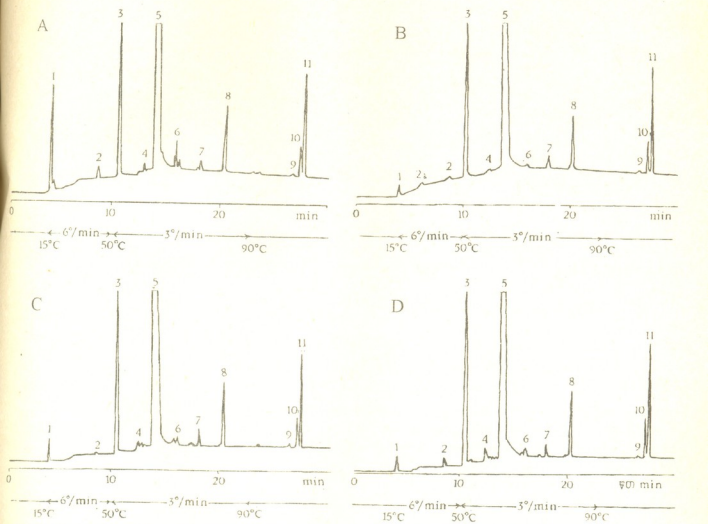

Fig.1. Vapour phase chromatograms of Georgian wines: A - *Hereti*, B - *Mukusani*, C - *Tibaani*, D - *Sameba*; 1- acetaldehyde, 2 - ethyl-acetate, 3 - methanol, 4 - butyl acetate, 5 - propanol, 6 - butanol, 7 - isoamyl spirit, 8 - H amyl spirit, 9 - ethylpalmitate, 10 - vanillin, 11 - furfurol.

Qualitative analysis was carried out by measuring time for assuming component inhibition contained in the wine vapour phase.

Control of the received chromatograms was carried out on the specially composed models of the identical content.

For quantitative interpretation of the received chromatograms absolute calibration method was used. For individual compounds the Table gives data according to the relative aromatic number for the above mentioned four Georgian wines.

Critical concentrations of certain compounds in wines are given in the works.

As seen from the work [6] and from the Table, the background of the flavour is determined by aliphatic spirits, esters and aldehydes.

Relative Values of Aromatic Number

Component	Wine			
	Hereti	*Mukusani*	*Tibaani*	*Sameba*
acetaldehyde	2.5	0.2	1.6	2.2
ethyl-acetate	0.6	1.2	1.5	1.3
methanol	0.1	0.2	0.1	0.4
butyl acetate	-	-	0.5	0.5
propanol	2.5	2.7	3.2	2.8
butanol	0.1	0.1	0.3	0.3
isoamyl spirit	2.5	3.5	2.6	2.4
H-amyl spirit	4.0	5.5	4.5	4.2
ethyl palmitate	0.5	2.0	1.2	0.2
vanillin	4.0	5.0	3.0	4.0
furfurol	3.5	-	3.5	5.5

It can be seen from the Table that in all the studied wines the comparatively high "aromatic number" corresponds to vanillin furfurol and H-aliphatic spirits.

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REFERENCES

1. *A. Shein.* Gazovaya khromatigrafiya v brodil'noy promyshlennosti. M., 1965 (Russian).
2. *G. Dickes, P. Nicolas.* Gas Chromatography in Food Analysis. London, Butterworth, 1976, 393.
3. *I. Sh Shatirishvili.* Khromatografiya gruzinskikh vin. Tbilisi, 1988, 170 (Russian).
4. *A. Williams, I.S. Lewis, H. V. May.* J. Sci. Food and Ayric. **34,** 3, 1983, 311.
5. *M. C. Meilyaad , I. Ayric.* Food Chem. 1982.
6. *Z. Kishkovsky, I. Scurikhin.* Wines Chem., 1986, 254 (Russuan).

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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ANALYTICAL CHEMISTRY

N. Takaishvili, T. Davitaia, G. Supatashvili

Turbidimetric Determination of Sulphates in Carbonate Strata

Presented by Academician G. Tsintsadze, December 22, 1997

ABSTRACT. **To determine micro and ultramicro quantity of SO_4^{2-} in carbonate strata and formations the turbidimetric method is used. Calcium ions influence upon $BaSO_4$ suspension optical density is excluded by the introduction of corresponding quantity of Ca^{2+} in standard series. The method sensitivity is 10 mkg, the standard deviation equals 0.7 - 1.0, the relative error is < 5%;**

Key words: carbonate strata, sulphates, turbidimetry, microanalysis.

To determine in sulphates carbonate strata and formations (carbonate of lime, stalactites, coral scum, etc.), because of its scrace content (0.01- 0.3% [1]), it is necessary to use highsensitive methods. From this point of view the most acceptable one is a turbidimetric method, which is successfully applied in hydrochemical analysis [2]. This variant of the method is easy to implement. It is distinguished by sensitivity and is quite precise (the relative error of > 10 mkg SO_4^{2-} determination is < 5%).

In the analysed volume the analysis weighed portion, proceeding from SO_4^{2-} optimal content (50-150 mkg in 5.0 ml), will keep within limits of 0.1-0.5 g. Its direct determination in the hydrochloric acid solution of the weighed portion gives enlarged results. The reason is an increase of $BaSO_4$ suspension optical density (D) in the presence of Ca^{2+} (Table 1). The effect can not be explained only by coprecipitation, as the stuff share of Ca^{2+} in formed suspension is only 0.8-1%. We think that at Ca^{2+} (also other electrolytes) the dispersion degree of $BaSO_4$ changes that is proved by existing data in literature [3,4].

Table 1

Ca^{2+} influence upon $BaSO_4$ suspension optical density (100 mkg SO_4^{2-})

Ca^{2+} mg/ml	D	Ca^{2+} mg/ml	D	Ca^{2+} mg/ml	D
0.0	0.140	2.0	0.170	10.0	0.222
0.5	0.150	4.0	0.190	12.0	0.227
1.0	0.152	6.0	0.205	14.0	0.235
1.5	0.165	8.0	0.215	18.0	0.240

The problem can be solved by masking Ca^{2+} or by considering its influence upon $BaSO_4$ suspension optical density.

From scanty reactants, aimed to mask Ca^{2+}, the best one is a complexion III (EDTA) [5]. But we could not receive desirable results, because of the EDTA limited solubility and the complexionate instability in the acid sphere (which is optimal for turbidimetric determination [2]). At the same time if the solution pH<2.7-3, the EDTA settles (initiating $BaSO_4$ suspension formation), but if pH> 5, Ba^{2+} in the settling reactant is partially

masked.

At the beginning to separate Ca^{2+} - SO_4^{2-} the ionometric method was used (KY - 2, In H^+ form). In the solution, because of Ca^{2+} high concentration (0.4 mol/l) the filtrate pH<1, so that it is necessary to neutralize Na_2CO_3, $NaHCO_3$, etc. At Na^+ ions $BaSO_4$ suspension optical density though a little but changes. From the analysis solution the macroquantity of Ca^{2+} can be separated by CaC_2O_4 precipitation. But according to the conditions, the coprecipitation of SO_4^{2-} happens by 3-5%. At the same time the method is greatly complicated by the necessity of surplus $C_2O_4^{2-}$ separation. Theoretically, pH=2 CaC_2O_4 solubility is equal to $2.1 \cdot 10^{-3}$ mol/l, but at forming $BaSO_4$ sediment, $C_2O_4^{2-}$ influence upon the suspension optical density is also noticed at 0.5-0.8. 10^{-4} mol/l. The solution pH falling < 2 is not acceptable even if the method sensitivity reduces (Table 2). It is a long process to separate $C_2O_4^{2-}$ from the solution by boiling or drying out and hitting dry residue at 200-300 ^{0}C.

Table 2

pH influence upon $BaSO_4$ suspension optical density (100 mkg SO_4^{2-}, 2 mg/ml Ca^{2+})

pH	D	pH	D	pH	D	pH	D
5.15	0.180	3.25	0.170	2.60	0.170	1.05	0.138
5.05	0.175	3.07	0.168	2.10	0.168	0.90	0.132
4.18	0.168	2.65	0.170	1.15	0.130	0.86	0.135

The analysis of the results shows that in carbonate strata and formations it is advisable to make SO_4^{2-} turbidimetric determination against a background of Ca^{2+}. The task is eased by the fact that in analysis objects Ca^{2+} content is practically constant and is close to theoretical (40%). Selecting Ca^{2+} background concentration it should be considered that $BaSO_4$ suspension optical density is the most stable at 7-15 mg/ml Ca^{2+} (Table 1) that in analysis volume (5ml) corresponds to 35-75 mg Ca^{2+}.

On the basis of the received information to determine sulphates in carbonate strata the following course of analysis is recommended: well loosened 500 mg weighed portion is put into 100 ml glass and dissolved 1:1 HCl. If necessary the glass is hitted, the solution is filtered and diluted to 25.0 ml. 5.0 ml solution (which pH should be within limits of 2-3) is transfered into 12-15 ml test-tube, 5.0 ml settling reactant is added, all is stirred by the ball stirrer and in 3-5 min the suspension optical density is measured (l = 20 mm λ = 400 nm).

2.5-2.5 ml "background" solution (buffer) and increasing quantity (0-2.5 ml) of standard solution are put in test-tubes to constract a calibration diagram. The mixture volume is led to 5.0 ml. 5.0 ml settling reagent is added and suspension optical density is measured.

If in the analysis object $CaCO_3$ content is less than 88-90%, Ca^{2+} concentration should be correspondingly reduced in "background" solution. The addition method that gives satisfactory results (Table 3), might be used, but it complicates the determination.

Solutions and Reactants.

a) SO_4^{2-} standard solution. The basic standard solution (titre 10 mg/ml SO_4^{2-}) is made by the recrystallized K_2SO_4. As a working standard we can use 0.002 NH_2SO_4.

b) $CaCl_2$ "background" solution. 1.00 g chemically pure $CaCO_3$ is dissolved in the

minimum quantity 1:1 diluted HCl and is diluted by distilled water to 25.0 ml. The solution should be tested on SO_4^{2-} content.

c) Settling reagent. 96% ethanol, ethylene glycol and 5% $BaCl_2$ solution are mixed by volume ratio 3:3:1. The diluted HCl reagent pH is led to 2.5-3.

Thus in carbonate strata and formations the micro and ultramicro quantity sulphates turbidimetric determination method is worked out. The precision is tested by the addition method (Tables 3 and 4). According to the results the determination standard deviation is equal to 0.7-1.0 and the relative error is < 5%.

Table 3

Sulphate content in carbonate strata and formations (%)

Object	Direct Determination	Addition Method
Carbonate of lime	0.045	0.043
Stalactite (the Athon cave)	0.022	0.021
Stalactite (the Thuse cave)	0.030	0.032
Coral (the Pacific ocean)	0.47	0.46
Travertin (the mineral source "Vedza-Deda", Khevsureti)	0.057	0.060

Table 4

SO_4^{2-} turbidimetric determination control results in stalactites (the addition method)

mkg			difference	
Taken	Added	Received	mkg	%
40	30	72	2	2.8
40	50	94	4	4.4
40	100	144	4	2.9
40	150	192	2	1.1
40	200	232	8	3.3
46	50	98	2	2.8
46	50	99	3	3.1
46	100	140	6	4.1
46	100	140	6	4.1

In carbonate strata the microquantity sulphate determination turbidimetric method was successfuly used to determine the acid corrosion degree of old architectural monuments. In the surface (0-2 mm), lower (2-4 mm) and deep (8-10 mm) strata of the famous Nickortsminda Cathedral walls the sulphur content proved to be 1.75; 0.14 and 0.12%. In carbonate strata the sulphur clark is 0.12%.

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REFERENCES

1. *G. V. Voitkevich.* Short Reference Book in Geochemistry. M., 1977. (Russian)
2. *G. D. Supatashvili.* Hydrochemical Materials, 33, 1963, 138-142 (Russian).
3. *N. A. Fygurovski, N. N. Ushakova.* The Stud. Laboratory, **18**, 8, 1952, 936-941 (Russian).
4. *C. Liteanu, H. Lingner.* Talanta **19**, 8, 1972, 945-952.
5. *I. V. Pyatnitski, V. V. Sukhan.* Masking and Demasking in Analytical Chemistry, M., 1990 (Russian).

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ORGANIC CHEMISTRY

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Synthesis of 5-aminoindole-2-carbonic Acid Products

Presented by Academician K.Japaridze, April 13, 1998

ABSTRACT. **N-acetyl-5-aminoindole-2-β,β-diethylethylenediamine - N-acetylated indole analogic novocaineamide was synthesized from 5-nitroindole-2-carbonic acid. To study its radiobiological properties Bunte salt S-[2-carbethoxy-5-indolylamino]acetylthiosulfate was used.**

Key words: 5-aminoindole-2-carbonic acid, radiobiological activity.

P-aminobenzoic acid product novocaineamide shows high antiarythmic properties [1]. Proceeding from the similar electric and spatial structure of P-amino benzoic acid and 5-aminoindole-2-carbonic acid (II), N-acetylated indole analogic novocaineamide was synthesized.

The initial substance 5-nitroindole-2-carbonic acid (II) was obtained from p-nitrophenilhydrazine. Interaction of the latter with pyrovinate and cyclization of the obtained hydrazone produced 5-nitroindole-2-carbonic acid ethyl ether (I), by soaping of which 5-nitroindole-2-carbonic acid was reduced. Carbonic acid (II) and thyonilchloride produced 5-nitroindole-2-carbonic acid chloranhydride (III) [2].

By interaction of chloranhydride (III) and β-diethylethylenediamine in ethylacetate a great yield (90%) of 5-nitroindole-2-β,β-diethylethylenediamine hydrochloride (IV) was obtained. By reducing the latter and acetylating the amine obtained (without isolation) the novocaineamide analogue N-acetyl-5-aminoindoil-2-β,β-diethyl-ethylendiamine (V) was synthesized.

To study the radiobiological properties S-[2-carbethoxy-5-indolylamino]acetylthiosulfate (VIII) was synthesized. The initial compound 5-aminoindole-2-carbonic ethylether (VI) gives high yield of chloracetylchloride products by the action of chloracetylchloride with the presence of sodium bicarbonate in dimethyl formamide. Bunte salt is obtained by the action of thiosulphate on compound (VII).

The structure of the compounds (IV, V, VII, VIII) was established basing on the data of elementary analysis, IR- and PMR-spectroscopy and mass spectrometry.

The mass spectrum of compound (5) shows the peak of molecular ion. Its mass number conforms to the presented structure. On decomposing the molecule (V) mainly the fragments with 244 and 201 mass numbers are obtained. It is caused by splitting off the diethylamino and β-diethylethylamino groups (Fig.2).

Radiobiological properties of S-[2-carbethoxy-5-indolylamino]acetylthiosulfate (VIII) were studied in the radiobiological laboratory of Sokhumi Institute of Experimental Pathology and Therapy.

The research of acetylthiosulphate was carried out on the mice irradiated with 1000-1100R after 15 min period of injecting the preparation. In the case of 180-360 mg/kg dose

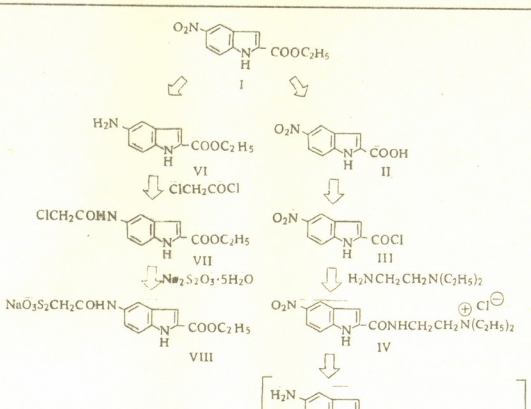

Fig.1

the reduction of radiation affect was observed which resulted in 15-18% prolongation of the mice life.

Spectra. IR spectra were obtained in vaseline oil on UR-20 and Perkin Elmer 457, mass spectra on a Varian-MAT-311A, BMR spectra on a Varian (USA), XL-200 (working frequency 200 MHz). Values of proton chemical resonance are given on δ-scale, the standard – tetramethylsilane.

5-nitroindole-2-β,β-diethylethylene diamine hydrochloride (IV). 1g (4.4 mmol) of 5-nitroindole-2-carbonic chloranhydride (III) solution in 80 ml of ethyl acetate was added by 0.6 ml (0.52 g, 4.5mmol) of β-diethylethylendiamine. Reaction ended up momentarily. Reaction mixture was allowed to stand for 12h. The crystals isolated were filtered. After recrystallization 1.36g (90%) of compound (IV) was obtained. $T_{m.p.}$ °C. 170-172; R_f = 0.20 (N-butanol-CH_3COOH-H_2O, 4:1:1); IR spectra (cm^{-1}): 3220 (NH), 1665, 1640(CO), 1520(NO_2), 2600 (NH^+Cl^-); elementary analysis: obtained (%) 52.62 (C), 6.23 (H), 10.09 (Cl), 16.11(N), $C_{15}H_{21}ClN4O_3$; calculated, (%): 52.86(C) 6.17 (H), 10.43 (Cl), 16.45 (N). PMR spectrum: δ, ppm ($CDCl_3$). 11.25 b.s. (1H), 7.02, S(3H), 8.64 d (4H) 8.16 d.d.(6H), 7.56 d (7H), 7.37 b.s. (COHH), 3.62m, 2.73t (CH_2CH_2), 2.65q(CH_2CH_3), 1.10t(CH_2CH_3). $J_{4,6}$ = 1.91 Hz, $J_{6,7}$ = 8.90 Hz, $J_{(CH_2CH_3)}$ = 5.72 Hz, J_{NHCH_2} = 5.09 Hz, $J_{CH_2CH_3}$ = 7.00 Hz.

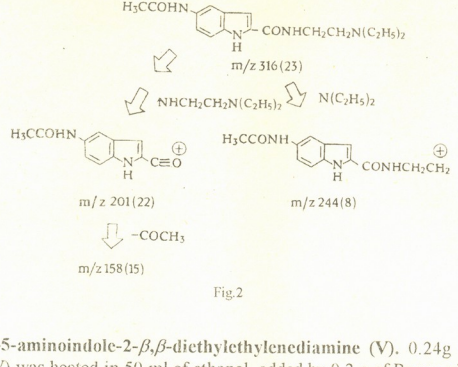

Fig.2

N-acetyl-5-aminoindole-2-β,β-diethylethylenediamine (V). 0.24g (0.7mmol) of compound (IV) was heated in 50 ml of ethanol, added by 0.2 g of Raney nickel and 5 ml of hydrazine-hydrate, filtrated after 2 h period and evaporated to a small amount. The residuum was added by 0.7 ml (0.7g, 7.0 mmol) of acetic anhydride and after 1h period 10 ml of water and 20 ml of izopropanol. After that it was extracted in vacuum. The remained oil was dissolved in 20 ml of izopropanol and precipitated by ether. The sediment was filtered. After recrystallization from izopropanol 0.2 g (91%) of acetylene product (V) was obtained: Tm.p.°C, 178-189; R_f = 0.08 (N-butanol-CH_3COOH-H_2O, 4:1:1); IR spectra (cm^{-1}), 3250 (NH), 1660 (CO); elementary analysis obtained: 64.79(C), 7.76 (H), 17.49(N), $C_{17}H_{24}N_4O_2$, calculated, %: 64.56(C), 7.59(H), 17.72(N); PMR-spectra, δ, ppm (d_6-acetone): 10.76b.s.(1H), 7.00d(3H), 8.08d(4H), 7.31d.d.(6H), 7.44d.(7H), 7.99b.s.(CONH), 3.51m, 2.74t((CH_2CH_2), 2.66q(CH_2CH_3), 1.07t(CH_2CH_3), 2.07S(CH_3O), 9.07b.s.(NHCOCH$_3$).$J_{1,3}$ = 1.36 Hz, $J_{4,6}$ = 2.20 Hz, $J_{6,7}$ = 8.90 Hz, J_{NHCH_2} = 5.85 Hz, $J_{CH_2CH_2}$ = 6.58 Hz, $J_{CH_2CH_3}$ = 7.00 Hz.

2-carbethoxy-5-[N-cloracetylamino]indole (VII). 1g (4.9 mmol) of 5-amino-2-carbethoxy indole (VI) was dissolved in 10 ml of dmfa, added by 1g of sodium bicarbonate and 0.6 ml (0.89 g 7.9 mmol) of chloracetylchloride with constant stirring. After 50 min period the reaction mixture was diluted with water and the sediment obtained was filtered. Chromatography of the residue was performed on a silica gel column (100/250) h = 50cm, d = 2 cm; eluate chloroform 1.25 g (91%) compound (VII) was obtained. $T_{m.p.}$, °C, 235-237; R_f = 0.79 (benzole-acetone, 1:1); IR spectra, cm^{-1}, 3320-3310 (NH), 1705 (CO ether.) 1675-1640 (CO amid.); elementary analysis, obtained, %: 55.21(C), 4.83 (H), 12.54 (Cl), 9.54 (N), $C_{13}H_{13}ClN_2O_3$, calculated, %: 55.61 (C) 4.63 (H), 12.66(Cl), 9.98 (N). PMR-spectra: δ, ppm. (d_6-acetone): 10.56 b.s (1H), 7.17 d. (3H), 8.13d.(4H), 7.45 d.d.(6H), 7.50 d.(7H), 4.36 q.($C\underline{H}_2CH_3$), 1.37t ($CH_2C\underline{H}_3$), 9.41 b.s. (NHCO), 4.26s (CH_3Cl). $J_{1,3}$ = 1.83 Hz, $J_{4,6}$ = 1.50 Hz, $J_{6,7}$ = 8.80 Hz.

S-[2-carbethoxy-5-indolylamino]acetylthiosulphate (VIII). 1.2 g (4.3 mmol) of compound (VII) in 50 ml of ethanol was heated to boiling, added by 2.48 g (10.0 mmol) of sodium thiosulfate in 5 ml of water. The reaction was going on for 5 h under the condition

of boiling and stirring. Gradually the mixture became transparent. Then it was extracted in vacuum up to dry residue. After recrystallization from methanol 1.4 g (87%) of Bunte salt (VIII) was obtained. $T_{m.p.}$ °C. 203-205; R_f=0.94 (N-butanol-CH_3COOH-water. 4:1:1): IR spectra (cm^{-1}). 3300-3130 (NH), 1720 (CO ether.), 1660-1610 (CO amid.). Elementary analysis. obtained, %: 7.34 (N), $C_{13}H_{13}N_2O_6S_2Na$; calculated, %: 7.37(N); PMR-spectra. δ ppm.(DMSO): 11.59 b.s. (1H), 7.08d.(3H), 7.93d.(4H), 7.30d.d. (6H), 7.40d.(7H). 4.34q(CH_2CH_3), 1.34t(CH_2CH_3), 9 94b.s.(CONH), 3.72S($COCH_2$). $J_{1.3}$ = 1.83 Hz, $J_{4.6}$ = 1.65 Hz, $J_{6.7}$ = 8.77 Hz, J(CH_2CH_3) = 7.00 Hz.

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REFERENCES

1. *I.I.L.Lertora, A.G.Alkinson.* Clim.Pharmacol. Ther. **25**, 3, 1979, 273-282.
2. *M.Shengelya, V.Avramenko, N.Suvorov.* Khim. form. Zhurn. **19**, 9, 1985, 1075-1078 (Russian)
3. *M.Shengelya, M.Vigdorchik, N.Suvorov, V.Abramenko.* Zhurn.Org.Khimia. **22**, 9, 1986, 1868-1873 (Russian).

ORGANIC CHEMISTRY

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Stereospecific Synthesis of α-substituted Derivatives of Glucose

Presented by Corr. Member of the Academy L.Khananashvili, April 4, 1998

ABSTRACT. **Simple process of obtaining a number of 1-substituted derivatives of acetylated glucose in the medium of liquid bromine is reported.**

Key words: cis-glycosides.

Glycosidic bond is the main type of bonds for all the most important natural compounds containing carbohydrates.

From numerous reactions leading to formation of glycosidic bonds only a few can solve complex problems of glycoside synthesis. Stereospecificity of substitution at glycosidic centre is one of the most important factors. Even in the case of relatively simple glycosides separation of anomers is quite a difficult task which is almost unsolvable while passing to the highest oligosaccharides and polysaccharides.

Glycosyl halides play an important role in carbohydrate chemistry and serve as initial compounds for synthesis of various derivatives of sugars by glycosidic centre. Halogen atom in acylohalogenoses easily undergo nucleophilic substitution. Condensation of 1,2-cis-acylglycosyl halides (1) with alcohols leads, as a rule, to 1,2-trans-glycosides, with conversion at C-I. This result might be the consequence of both the S_N2 reaction and the monomolecular heterolysis of C-1-halogen bond leading to glycoside-cation (II). The latter is immediately stabilized by the intramolecular neucleophilic attack of ester group at C-2 forming cyclic acyloxon ion (III). Attack of alcohol to glycosidic centre of this ion leads to 1,2-trans-glycoside (IV). That is why monomolecular reactions of acylglycosyl halides, which had to lead to anomer formation, in fact due to stereochemical control with the participation of neighboring acyloxygroup [1] are proceeding stereospecifically (Fig.1).

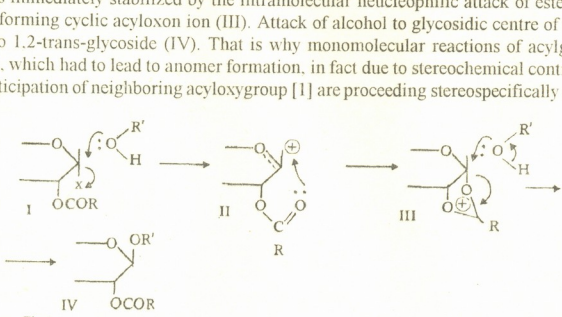
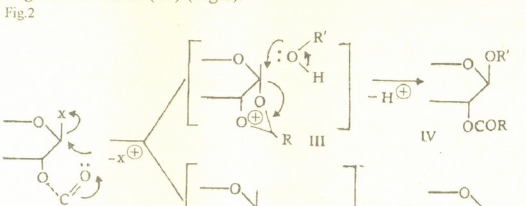


Fig.1

Reactions of 1,2-trans-acylglycosyl halides (V) with alcohols, as a rule, are proceeding by monomolecular heterolysis of C-1-halogen on the account of cooperation of neighboring acyloxygroup. Formed acyloxonium ion (III) can further act with alcohol either forming 1,2-trans-glycoside (as mentioned above) or with straight alcohol attack to the

centre leading to ortho-ester (VI) (Fig.2).

Fig.2

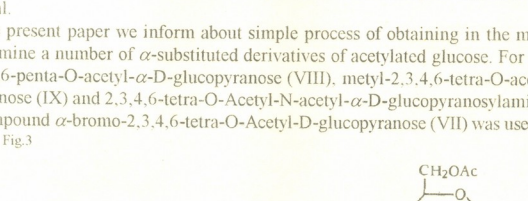


III

Compared with 1,2-trans-glycoside, general methods of 1,2-cis-glycosides are not being worked out till now, which makes the problem of chemistry of natural compounds very actual.

In the present paper we inform about simple process of obtaining in the medium of liquid bromine a number of α-substituted derivatives of acetylated glucose. For synthesis of 1,2,3,4,6-penta-O-acetyl-α-D-glucopyranose (VIII), metyl-2,3,4,6-tetra-O-acetyl-α-D-glucopyranose (IX) and 2,3,4,6-tetra-O-Acetyl-N-acetyl-α-D-glucopyranosylamine (X) as initial compound α-bromo-2,3,4,6-tetra-O-Acetyl-D-glucopyranose (VII) was used (Fig.3).

Fig.3



For establishment the product yield the reaction was held for 5, 10, 20 and 30 minutes. We found that the best yield for (IX) compound we get holding the reaction for 10 min. and for (VIII and X) while holding the reaction for 20 min.

Yield, constants, data of elementary analysis, time of the reaction are summarized in Table 1.

1,2,3,4,6-Penta-O-Acetyl-α-D-glucopyranose (VIII). To the solution of 5.7 g of acetobromoglucose into 6 ml bromine 6 ml of acetic acid was added, stirred for 20 min at room temperature and 15 ml of water was added. Then all this was poured into water solution of sodium sulphate with ice to avoid excess of bromine. The compound was

extracted with ether. Ether solution was dried with sulphite sodium and evaporated. Residue was crystallized from 45% ethanol. Yield 4.14 g (76.6%). M.p. 108-109°C. $[\alpha]_D^{18}$ +104.0° (C 0.44, chloroform). According to the data [2]: M.p. 112-113°C. $[\alpha]_D$+102° (chloroform). Found %: C 48.52;H 4.98. Calc. for $C_{16}H_{22}O_{11}$, %: C 49.23. H 5.6.

Table 1

Compound	Duration of experiment (min)	Yield, %	$[\alpha]_D$ ($CHCl_3$)	M.p. °C	Found, %			Brutto formula	Calculated, %		
					C	H	N		C	H	N
VIII	5	28.1	108	101-103	49.92	6.1	-	$C_{16}H_{22}O_{11}$	49.23	5.6	-
	10	60.7	107.3	100-102	48.44	5.8	-	$C_{16}H_{22}O_{11}$	49.23	5.6	-
	20	76.6	104	108-109	48.52	4.98	-	$C_{16}H_{22}O_{11}$	49.23	5.6	-
IX	5	10.2	120	95-97	48.72	5.82	-	$C_{15}H_{22}O_{10}$	49.47	6.08	-
	10	48.1	124	96-97	50.22	6.72	-	$C_{15}H_{22}O_{10}$	49.47	6.08	-
	20	40.1	110	92-93	49.80	6.40	-	$C_{15}H_{22}O_{10}$	49.47	6.08	-
X	5	4.9	20.1	Syrup	51.72	5.68	3.44	$C_{16}H_{23}O_{10}N$	50.0	6.0	3.6
	10	15.5	26.5	117-119	49.4	5.92	3.26	$C_{16}H_{23}O_{10}N$	50.0	6.0	3.6
	20	57.5	28.6	118-119	49.82	6.04	3.3	$C_{16}H_{23}O_{11}N$	50.0	6.0	3.6

Methyl-2,3,4-tetra-O-Acetyl-α-D-glucopyranose (IX). To the solution of 5.7 g of acetobromglucose into 6 ml of bromine 10 ml of methanol was added and stirred at room temperature for 10 min. Then 10 ml of water was added and poured into water solution of sodium metabisulphite with ice to avoid the excess of bromine. The compound was extracted by ether. Ether solution was washed with cold water, dried with sodium sulphate and evaporated to dryness. Residue was crystallized from ethanol. Yield 2.41 g (48.1%). M.p. 96-97°C. $[\alpha]_D^{16}$ +124° (C 0.6, chloroform). According to the data [3]: M.p. 100-101°C. $[\alpha]_D$+131° (chloroform). Found %: C 50.22. H 6.72. Calc. for $C_{15}H_{22}O_{10}$ %: C 49.47. H 6.08.

2,3,4,6-tetra-O-Acetyl-N-Acetyl-α-D-glucopyranosylamine (X). To the solution of 5.7 g of acetobromglucose into 6 ml of bromine 6 ml of acetonitrile was added, stirred for 20 min. at room temperature and poured into water solution of sodium metabisulphite with ice to avoid bromine excess. The compound was extracted with ether. Ether solution was washed with water, dried with sodium sulphate and evaporated. Residue was crystallized from ethanol. Yield 3.61 g (57.5%). M.p. 118-119°C. $[\alpha]_D^{17}$ +28.6° (C 0.53, chloroform). According to the data [4] M.p. 121°C. $[\alpha]_D$+137.2° (chloroform). Found %: C 49.82. H 6.04. N 3.3. Calc. for $C_{16}H_{23}O_{10}N$ %: C 50.0. H 6.0. N 3.6.

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REFERENCES

1. *A.Bochkov, V.Afanasyev, G.Zaikov*. Obrazovanie i raschepleniye glikozidnikh svyazei. M., 1978 (Russian).
2. *W.Koenigs, E.Knorr*. Ber., 1901, 34, 369.
3. *Cp.Th. L.Harris, E.L.Hirst, Ch.E.Wood*. Soc., 1932, 2108.
4. *P.Brigl, H.Keppler*. Z.Physiol. Ch., 1929, 180, 38.

ORGANIC CHEMISTRY

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Methylsiloxane Oligomers with Thioalyl Fragments in the Side Chain

Presented December 12, 1997

ABSTRACT. **The reaction of hydrid polyaddition of alylmercaptan to α,ω-bis(trimethylsiloxy)methyl hydridsiloxane in the presence of platinium chlorhydric acid as a catalyst has been investigated. It was established that besides hydrid polyaddition the reaction was partially accompanied by the reaction of dehydrocondensation. Catalytic dehydrocondensation of alylmercaptane with α,ω-bis(trimethylsiloxy)methylhydridsiloxane in the presence of powdered anhydrous potassium hydroxide proceeds with the formation of comb type systems with thioalyl fragments in the side chain. The reaction order, activation energies and dehydrocondensation rate constants have been found. Thermogravimetric, thermomechanical and roentgenographic investigations have been carried out.**

Key words. hydrid polyaddition, catalytic dehydrocondensation.

As it is known, the siliconorganic oligomers containing Si-O-C bonds in the chain in neutral area are characterised by hydrolytical stability. It was interesting to obtain siliconorganic oligomers with thioalyl and propylthioalcohol fragments in the side chain.

The reaction of hydrid polyaddition of alylmercaptan with α,ω-bis(trimethylsiloxy)methylhydrid-siloxanes in the presence of 0.1 M solution of platinium chlorhydric acid (in isopropyl alcohol) as a catalyst has been investigated.

From literature [1] it is known that the reaction of alylmercaptan with hydridmethyl siloxanes may proceed by following competitive reactions:

1) by hydrid polyadditions on unsaturated groups:

$$\equiv Si\text{-}H + CH_2{=}CH\sim \xrightarrow{H_2PtCl_6} \equiv Si\text{-}C_2H_4\sim$$

2) by the catalytic dehydrocondensation of Si-H and HS -mercapto groups:

$$\equiv Si\text{-}H + HS\sim \xrightarrow{H_2PtCl_6} \equiv Si\text{-}S\sim + H_2$$

It was found that at 60^0C the reaction of catalytic dehydrocondensation takes place and for 7h the conversion of active Si-H groups is about 6.5-7%, while the reaction of hydrid polyaddition proceeds by 40-44% conversion of active Si-H groups. So, in this case oligomers with anomal structure are obtained, whose macro chain contain branching units with thioether and carbosilane ones. Because of this, the reaction may proceed according to the following scheme:

$$Me_3SiO\text{-}[SiMe(H)O]_m\text{-}SiMe_3 + mCH_2{=}CH\text{-}CH_2SH \xrightarrow{H_2PtCl_6}$$

$$\rightarrow Me_3SiO\text{-}\left[\left(\begin{array}{l}Me\\|\\Si-O\\|\\C_3H_6\\|\\SH\end{array}\right)_b-\left(\begin{array}{l}Me\\|\\Si-O\\|\\H\end{array}\right)_n-\left(\begin{array}{l}Me\\|\\Si-O\\|\\S\\|\\CH_2\\|\\CH=CH_2\end{array}\right)_k-\left(\begin{array}{l}Me\\|\\Si-O\\|\\H\end{array}\right)_q\right]\text{-}SiMe_3$$

I

$m \approx 53$

Subsequently the heating of the reaction mixture leads to obtaining of sewing systems on account of intrachain and interchain reactions of side functional groups:

$$\equiv Si\text{-}C_3H_6\text{-}SH + H_2C{=}CH\text{-}CH_2\text{-}S\text{-}Si \equiv \xrightarrow{H_2PtCl_6} \equiv Si\text{-}C_3H_6\text{-}S\text{-}C_3H_6\text{-}Si \equiv$$

$$\equiv Si\text{-}H + CH_2{=}CH\text{-}CH_2\text{-}S\text{-}Si \equiv \xrightarrow{H_2PtCl_6} \equiv Si\text{-}C_3H_6\text{-}S\text{-}Si \equiv$$

Table

Some physico-chemical properties and elementary analysis of oligomers

Oligomer N	Yield, %	η_{sp} 1% solution in Toluene, 25^{0}C	T_{vitr}, ^{0}C	d_1, Å	Elementary analysis, %			
					C	H	Si	S
I	45.2	0.063	-92	6.56	35.86 35.47	7.47 7.15	21.66 21.30	23.05 23.28
II	38.3	0.031	-117	9.83	29.86 29.49	6.48 6.15	32.20 31.87	13.38 13.05
III	56.8	0.050	-	-	35.23 35.01	6.76 6.30	29.74 29.40	18.54 18.25
IV	63.4	0.061	-112	9.83	33.15 32.81	6.33 6.02	26.93 26.40	18.46 18.08

in numerator there are calculated values and in denominator-found values

The obtained oligomer I is a yellow solid system unsoluble in organic solvents. For the purpose of synthesis of easily hydrolyzable and soluble silylthioethers the reaction of catalytic dehydrocondensation of alylmercaptan with α,ω-bis(trimethylsiloxy)methylhydridsiloxanes in the presence of anhydrous powderlike potassium hydroxide has been carried

out. In case of 0.1 mass% catalyst of anhydrous potassium hydroxide the reaction proceeds slightly for 5 h. The conversion of Si-H groups is about 10%. The optimal version of amount of potassium hydroxide was chosen 0.5 mass % of catalyst and the temperature range 50-70^{0}C. In these conditions the reaction is not complicated by secondary processes. The reaction of catalytic dehydrocondensation proceeds according to the following scheme:

$$Me_3SiO\text{-}[SiMe(H)O]_m\text{-}SiMe_3 + mHS\text{-}CH_2\text{-}CH{=}CH_2 \xrightarrow[-H_2]{0.5\%KOH,\ T^0C}$$

$$\rightarrow Me_3SiO\text{-}\left[\begin{array}{l} Me \\ | \\ Si-O \\ | \\ S \\ | \\ CH_2 \\ | \\ CH=CH_2 \end{array}\right]_n - \left[\begin{array}{l} Me \\ | \\ Si-O \\ | \\ H \end{array}\right]_{m-n} \text{-}SiMe_3$$

Where: $n \approx 53$, II (50^{0}C), III (60^{0}C), IV(70^{0}C).

It must be denoted that the reaction does not proceed completely and replacement of all active Si-H groups doesn't occur impeded. This may be explained by steric effects created by thioalyl fragments. With an increase of temperature from 50^{0}C up to 70^{0}C, the depth of catalytic dehydrocondensation increases from 35 up to 60%. Dehydrocondensation reaction of methylhydridsiloxanes with alylmercaptans proceeds with more difficulty and slower than hydroxy(alkylthio)ethanes.

Consequently the reaction of catalytic dehydrocondensation may easily proceed with hydroxy(alkylthio)ethenes than with alylmercaptans (KOH~0.5 mass%). Dehydrocondensation reactions of methylhydridsiloxanes with alylmercaptans for 20 minutes (at the beginning) proceeds vigorously, after that the conversion of active Si-H groups is insignificant. By gas-liquid chromatography the presence of unreacted alylmercaptan was shown. In the IR spectra of oligomers one can observe absorption bands characteristic of asymmetric valence vibrations of the Si-O-Si bonds in the region 1020 cm^{-1} for the linear siloxane links, absorption bands for the Si-Me groups at 1270 cm^{-1}, for the SiMe groups at 840 cm^{-1} and for the C-S bond at 700 cm^{-1}. One can observe also absorption bands for the unreacted active Si-H groups in the region 2160 cm^{-1}. From the dependence of inverse concentration on the time one can see that catalytic dehydrocondensation on the starting stages is of the second order.

The reaction rate constants at various temperatures were calculated: K_{50^0C}= 1.8008, K_{60^0C} = 2.7528 and K_{70^0C} = 4.289. It was found that for each increase in temperature of the reaction about 10^{0}C, the reaction rate constants increase, so the temperature coefficient γ=1.5. The activation energies of catalytic dehydrocondensation reaction was calculated $E_{activ.}$=38 KJ/Mole. Increasing value of activation energy of the reaction shows .

that dehydrocondensation of alylmercaptans with methylhydridsiloxanes proceeds less actively than dehydrocondensation of hydroxy(alkylthio)ethanes with methylhydridsiloxanes [2].

The thermomechanical investigation of oligomers II— IV was performed and as it is evident from the Table the T_{vitr} of oligomers are about -92 ,-117^{0}C. Roentgenographic analysis shows that the oligomers I,IV are one-phase amorphous systems and interchain distances is about d_1= 9.83 Å. for oligomer IV this value of d_1 is close to the value of d_1 characteristic of siliconorganic oligomeric ethers with alkylthioethane fragments in the side chain.

The thermogravimetric investigations show that 5% mass loss is observed at the temperature 200^{0}C and the main destruction process proceeds in temperature range 200-500^{0}C and at 720^{0}C mass loss does not occur. Residual mass for oligomer IV is~ 51%.

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REFERENCES

1. *N.S. Nametkin, A.V. Topchiev, T.I. Chernisheva.* Investigations in the Field of Siliconorganic Compounds, M., 1962, 56 (Russian).
2. *A.V.Topchiev, N.S.Nametkin, T.I.Chernisheva, S.G. Durgarian.* J. Prakt. Chem., 9, 82, 1959 (Russian).

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PHYSICAL CHEMISTRY

G. Lekishvili

The Models Based on Optimization

Presented by Academician T. Andronikashvili 15, 1997

ABSTRACT. **The temperature dependent molecular descriptors have been introduced considering the statistical distribution of conformers. The presented results enable to optimize synthesis not only via structure, but also via temperature.**

Key words: molecular descriptor, Wiener number, 3D indices, conformer, statistical distribution.

Application of the method of topological indices enables one to design molecules with the given properties. However, behavior of molecules depends not only on their structure, but also on the reaction conditions e.g. temperature. So far there have been introduced more than 120 indices, but none of them is temperature dependent [1].

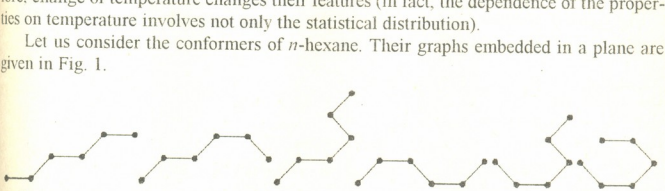
Molecules can have different conformers. Their distribution depends on temperature [2]:

$$\langle E \rangle = \frac{\sum_i E_i \exp(-E_i / k_B T)}{\sum_i \exp(-E_i / k_B T)}. \qquad (1)$$

Here $\langle E \rangle$ is the average energy, E_i is the energy of the i^{th} conformer, k_B is the Boltzmann number and T is the temperature in Kelvins.

The properties of molecules are significantly determined by this distribution. Therefore, change of temperature changes their features (in fact, the dependence of the properties on temperature involves not only the statistical distribution).

Let us consider the conformers of *n*-hexane. Their graphs embedded in a plane are given in Fig. 1.



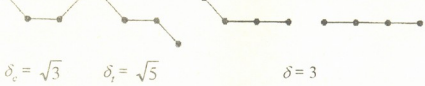
$^3W_1 = 27.3607$ $^3W_2 = 25.8486$ $^3W_3 = 24.8406$ $^3W_4 = 24.3366$ $^3W_2 = 23.8326$ $^3W_2 = 22.3205$

Fig. 1. The graphs of the *n*-hexane conformers embedded in a plane

The first conformer must have the lowest energy, as the distribution of electron density is the most uniform, i. e. more compact conformers have higher energies (at the absence of hydrogen bonds).

There have been suggested many 3D descriptors useful for compactness of evalua-

tion [3,4]. In the present paper we shall apply the method of the basic subgraphs [5,6].



$\delta_c = \sqrt{3}$ $\delta_t = \sqrt{5}$ $\delta = 3$

Fig. 2. The basic subgraphs

The path length between the i^{th} and j^{th} vertices can be calculated as follows

$$d_{ij} = \sum_{k=1}^{n} \delta_k - 2(n-1); \; W = \frac{1}{2}\sum_i \sum_j d_{ij} \tag{2}$$

Here δ_k is the basic subgraph length computed in terms of the grid coordinates method [1,3], n is the number of the basic subgraphs in the "classical" path [7]. One can easily note that d_{ij} is equal to the number of the edges between i and j when the graph is linear.

In order to construct a temperature dependent molecular descriptor, we should not accept that $E_i \sim W_i^{-1}$. Now we can introduce the descriptor as

$$<W> = \frac{\sum_i W_i \exp(-\nu / W_i T)}{\sum_i \exp(-\nu / W_i T)} \tag{3}$$

Here ν is the free parameter [5]. E. g. for the n-hexane conformers, the values of the temperature dependent descriptors are the following (when $\nu = R^{-1}$):

T = 1K	$<W>$ = 24.740386	ΔH_f = 30.91
T = 298.15K	$<W>$ = 24.739803	ΔH_f = 39.96
T = 400K	$<W>$ = 24.739802	ΔH_f = 42.46

Considering the presented results, one may hope that the outlined model enables us to carry out synthesis optimization not only via structure, but also via the reaction conditions.

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REFERENCES

1. *A. T. Balaban.* In: From Chemical Topology to Three Dimensional Geometry. Edited by A. T. Balaban, Plenum Press. New York and London, 1966.
2. *J. E. Mayer, M. G. Mayer.* Statistical Mechanics, Moscow, 1980 (Russian).
3. *M. Rondic, B. Jerman-Blazic, N. Trinajstic.* J. Comput. Chem. 14, 1990, 237-246.
4. *S. S. Tratch, R. O. Devdariani, N. S. Zefirov.* Zh. Organ. khim. 26, 1990, 927-932 (Russian).
5. *G. Lekishvili.* J. Chem. Int Comput. Sci. v.37, N5, 1997, 924-928.
6. *G. Lekishvili.* J. Chem. Inf. Comput. Sci.
7. *F. Harary.* Graph Theory. Moscow, 1973 (Russian).
8. *V. A. Kireev.* Methods of Practical Calculations in Thermodynamics of Chemical Reactions. M., 1975, 470.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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PHYSICAL CHEMISTRY

T. Butkhuzi, N. Kekelidze, M. Sharvashidze, L. Aptziauri, L. Kuchukashvili, E. Chikoidze

Ionic Annealing of Zinc Sulfide by Ag^+

Presented by Academician J.Lominadze, December 17, 1997

ABSTRACT. **ZnS crystals of impure P-type conductivity are obtained. The interpretation of observed peaks at different temperatures of ZnS photoluminescence spectrum is given.**

Key words: compensation, photoluminiscense, implantation.

Thermodynamic analysis was carried out in A_2B_6 wide band-gap compounds in order to receive impure hole conductivity. Heat treatment temperature at which the existence of uncompensated, free charge carriers is theoretically permissible has been estimated.

Two mechanisms are regarded during implantation of impurities in crystal: origin of free charge carriers and formation of a new, free charge compensated defect [1]. Thus the critical temperature is expressed by:

$$T^0 = \frac{H_{V_B} - E_i + E_d}{\Delta S_2 - \Delta S_1} \leq 400^\circ C$$

where T^0 is the temperature, below which it is possible to obtain hole conductivity in ZnS while implanting Ag^+ ions [2].

Before annealing the surface of ZnS was covered by active protective coat (APC) of 60-80Å thickness, which protects the sample surface from damage during annealing.

Radiation doses of ionic annealing are $10^{14} \div 10^{15}$ cm^{-2}, whereas energy is E = 30÷50keV.

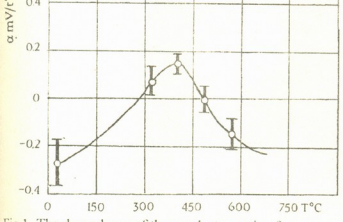

Fig.1. The dependence of thermoelectromotive force coefficient during the existence of APC implanted by Ag^+ at annealing temperature of ZnS.

In the range of T = 350÷400°C while heat treatment in photoluminescence spectrum of obtained sample λ = 454 nm corresponding peak has been observed. The measurements of thermoelectric power (TEP) in these samples point to the existence of weak hole conductivity (Fig.1). This result agrees with theoretically estimated meaning of critical temperature. We have studied the receiving of low-resistant impurity hole conductivity in ZnS. Implantation occurs by S^+ ions, and the sample is covered by Ag 100÷150Å layer thickness. While implantation silver is implanted into crystal. In the course of using

such technology complete scattering of silver layer doesn't occur. After the implantation heat treatment of the sample occurs by using Ag. The annealing takes place in ZnS powder or in Ag. The temperature interval of heat treatments is T = 400÷800°C.

Inversion of conductivity type takes place after implantation on T>450°C during heat treatment. T = 600÷650°C can be regarded as critical temperature during ADF existence in case of heat treatment. Specific resistance is $P = 10^{2} \div 10^{3}\ \Omega$cm.

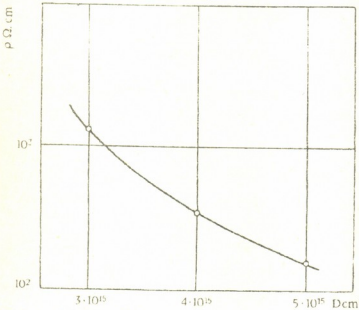

Fig.2. Implanted by S^{+} dose dependence of ZnS specific resistance implanted by S^{+} during the existence of APC. Annealed at 650° C while Ar annealing.

Fig.2 illustrates nonlinear dependence between specific resistance and doses. The increase of S^{+} ion doses causes saturation of silver by sulfur. Ag_2S is formed as a result of which the transition of S into APC from ZnS base crystal stopped. Compensated defect function in the system ZnS-Ag_2S will be fulfilled by $V_S^{\bullet\bullet}$. This defect corresponds to E = 1.05eV and performs the role of deep acceptor. Because of a compensating charge the existence of $V_S^{\bullet}$ prevents the formation of hole type conductivity. Due to the fact that $V_S^{\bullet}$ concentration decreases at the expense of recharge then hole conductivity will increase more rapidly than before Ag. The energetic location of the acceptor centre makes E = 0.3±0.03eV (Fig.3). It is supposed that this level is conditioned by impuring acceptor centre of Ag. After the implantation of the sample by S^{+} ions the removing of APC and heat treatment is going on. In the photoluminescence spectrum of the obtained samples there was observed the peak of intensive radiation λ = 454nm. The hole conductivity has not been observed in these samples.

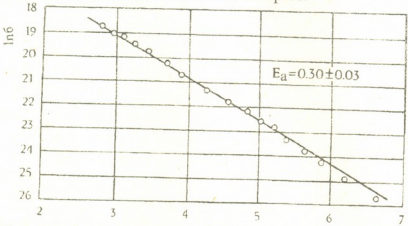

Fig.3. During APC implanted by S^{+} temperature dependence of ZnS conductivity. Annealed at 650°C.

During the existence of the protective layer by heat treatment of samples at T = 700°C, weak hole conductivity has been obtained. In PL spectrum weak peak λ = 454nm and vividly seen peak λ = 520nm. λ = 454nm appears only during strong compensation of free

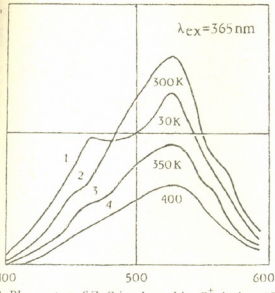

Fig.4. PL spectra of ZnS implanted by S^+ during APC existence at various temperatures. Heat treatment occurs in Ar at annealing temperature 700°C while APC of Ag exists.

charge carriers. This peak corresponds to the existence of $Ag'_{Zn} - V_S^{\bullet}$ associates. In case of weakening of selfcompensation and compensation mechanisms, i.e. double charge of $V_S^{\bullet}$, isolated defect $V_S^{\bullet\bullet}$ is obtained. This defect in photoluminescence spectrum causes the appearance of λ = 520nm peak (Fig.4).

The intensity of λ = 470nm peak is decreasing in PL spectrum of P-type. This fact is connected with the reduction of Zn_i concentration.

In samples which annealing is going on during the existence of protective layer, corresponding peak λ = 454nm is increasing. During the solution of sulfur, in silver layer because of high concentration of $V_S^{\bullet}$, $V_S^{\bullet} - Ag'_{Zn}$ associate is obtained, which is connected with radiation in PL spectrum λ = 454nm.

Without protective layer while heat treatment in PL spectrum λ = 454nm is almost unobservable. This is caused by the fact that a small amount of silver is implanted in Zn sublattice and the main dotted defect is interjunction silver Ag_i. Thus, the $V_S^{\bullet} - Ag'_{Zn}$ associate formation doesn't take place.

It is shown that the role of low temperature ionic implantation is expressed in diffuse stimulation. After establishing of thermodynamic equilibrium the annealed sample is the carrier of those electric and optic properties which corresponds to used thermodynamic parameters.

Taking into account the role of ionic implantation ZnS crystals of impure P-type conductivity are obtained. The interpretation of observed peaks of ZnS photoluminescense spectrum is given.

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REFERENCES

1. *C.H.Park, D.J.Chadi.* Appl. Phys. Lett. 66, 1995, 3167.
2. *K.W.Kwak, R.D.King-Smith et al.* Phys. Rev. 48, 1993, 17827.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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PHYSICAL CHEMISTRY

N. Kekelidze, L. Akhalbedashvili, M. Alapishvili, I. Davituliani, D. Tsintsadze, P. Euthymiou, N. Gouskos

Interaction of HTSC-samples with Water

Presented by Academician T. Andronikashvili, May 18, 1998

ABSTRACT. **Water effect on Y-Ba-Cu-O and Bi-Sr-Ca-Cu-O types of superconductors was studied by pH-method. It was suggested that the interaction of HTSC with water should proceed in the following way: first water is sorbed on the surface of samples and interacts with Ba, Ca and Sr ions forming of corresponding hydroxides. These hydroxides underwent carbonization and blocked the surface. Bi-containing structure is more stable to water, than that of Y-Ba-Cu-O.**

Key words: superconductors, chemical degradation, hydrolysis, pH solution.

The practical use of high temperature superconducting materials (HTSC) suggests the study of their stability in keeping and exploitation, because HTSC are known to be destroyed under the action of gas components medium, especially water vapours and carbon dioxide [1]. The degradation is caused not only by high oxidative ability of those compounds, but also by specific layered construction of their crystal structure. As a result of this interaction phase is destroyed forming such reaction products as Y_2BaCuO_5, $Ba_2Cu(OH)_5$, $Y(OH)_3$, $Ba(OH)_2$, $BaCO_3$, CuO [2,3]. Their correlation depends on temperature and time of interaction. The degradation of structures on Bi-base has been studied in a less degree.

In present paper we have studied the stability of $YBa_2Cu_3O_{7-x}$ and $Bi_2Sr_2Ca_2Cu_3O_x$ in aqueous medium using pH-measurements.

The samples were obtained by means of traditional ceramic method [4] with wet grinding. The required amounts of ittrium oxide, barium carbonate and cupric oxide for samples NN1,2 (see Table), and vismut nitrate, stroncium, calcium and cupric oxides for samples NN3,4 were mixed well under absolute ethyl alcohol. The mixture was dried and exposed to thermal treatment at 930^0C ($YBa_2Cu_3O_{7-x}$) and at 800^0C ($Bi_2Sr_2Ca_2Cu_3Ox$) during 10h in air. The mixture was then furnaced, cooled, pulverized and calcinated at the same temperature. The obtained powder was pressed into circular disks with d = 8mm and l = 1mm. Y-containing and Bi-containing samples were sintered at 950^0C and 820^0C during 4 h respectively, then cooled up to 450^0C and left at this temperature for 4 h again cooled slowly up to room temperature flowing oxygen.

Samples electroconductivity was measured by the four point probe methods using silver-paste contacts. The critical temperature of superconductive transfer was T_c = 94.5 K and ΔT_c = 2.2 K for $YBa_2Cu_3O_{7-x}$ samples and T_c = 82 K, ΔT_c = 2.2 K for $Bi_2Sr_2Ca_2Cu_3O_x$ (Fig.1). Phases identification was carried out by X-ray analysis and according to [5,6]. It was found that ittrium samples had typical for $YBa_2Cu_3O_{7-x}$ rhombic phase with a = 3.8250, b = 3.8895, c = 11.6749, but Bi-containing structures about 80% of phase tetragonal volumecentric lattice.

Table

N	Sample	x	T_c, K	ΔT_c	T_{water} °C	Delay time, (h)	$pH_{initial}$	pH_{final}
1	$YBa_2Cu_3O_{7-x}$	0.35÷0.28	94.5	2.2	25	24	9.0	13.1
2	$Bi_2Sr_2Ca_2Cu_3O_x$	-	82	2.8	25	24	8.4	11.0
3	$YBa_2Cu_3O_{7-x}$	0.35÷0.28	94.5	2.2	80	24	9.8	13.0
4	$Bi_2Sr_2Ca_2Cu_3O_x$	-	82	2.8	80	24	9.5	10.2
5	$YBa_2Cu_3O_{7-x}$ (peliet)	0.35÷0.28	94.5	2.2	25	4	8.0	11.4
						24	8.0	12.0

The study of water effect was carried out by pH-method. Prepared powder or circular samples were placed in bidistilled water at 25°C and 80°C in air. The measurement of pH solution was recorded at certain intervals over 24 h using pH-meter of 673-M model. At the end of the experiment the solution was decanted off, the pressed sample was washed gently with acetone, dried and prepared for resistance measurements. Specific resistance of ceramics hydrated at room temperature increased about three times but samples, treated with water at 80°C showed an increase of resistance in three orders for Y-containing samples and in 2.5 orders for Bi-containing ones. The beginning of superconduct transition temperature of samples N1 and N2 remained the same-94.5 K and 82 K respectively.

The changes of pH solution as a function of time dependence are shown in Fig.2. The pH solution of samples N1 and N3 sharply jumped from 7.5 to 12.5 within the first 15 min, then rose up to 13 more slowly for N3, which was treated by water at 80°C. Later we observed the stable motion of pH, but it increase slightly after 24 h.

The decrease of the value of the pH solution after the exposure of samples during few days in air up to 10.2 was obtained, which is probably the result of carbonization of formed hydroxides of rare-earth metals such as $Ba(OH)_2$, $Sr(OH)_2$, $Ca(OH)_2$ under scheme:

$$R(OH)_2 + CO_2 \text{ (from air)} \rightarrow RCO_3 + H_2O$$

Bi-containing samples differ from $YBa_2Cu_3O_{7-x}$ by lower values of pH solutions, though

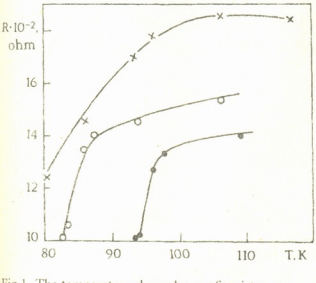

Fig.1. The temperature dependence of resistance:
• - initial $YBa_2Cu_3O_{7-x}$; ∘ - initial $Bi_2Sr_2Ca_2Cu_3O_x$;
x - $YBa_2Cu_3O_{7-x}$ after hydrolysis.

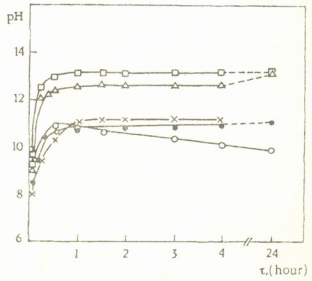

Fig.2 Variation of solution pH with time:
• - sample N2; ∘ - N4, Δ - N1; □ - N3;
x - N5.

full hydrolysis time is practically the same. The surface of the solutions of samples N1 and N3 was covered by a white layer in first minutes. This layer was found to be barium hydroxide which is the main product of hydration. The solution of Bi-containing samples remained clean.

This fact is in good agreement with data, that Ba^{2+} ion in Y-containing samples is very mobile and easily reacts with water, but $Ba(OH)_2$ is characterized by a higher solubility, than $Sr(OH)_2$ and $Ca(OH)_2$ and therefore $Ba(OH)_2$ goes out of bulk into solution more easily and undergoes carbonization. The time of full hydrolysis at room temperature is about 10 days.

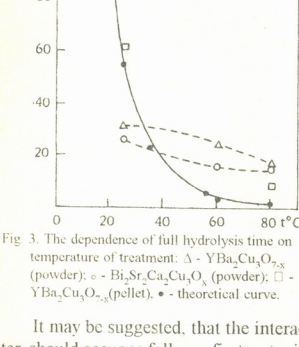

Fig. 3. The dependence of full hydrolysis time on temperature of treatment: Δ - $YBa_2Cu_3O_{7-x}$ (powder); ○ - $Bi_2Sr_2Ca_2Cu_3O_x$ (powder); □ - $YBa_2Cu_3O_{7-x}$(pellet). • - theoretical curve.

We compared our results with functional relationship between time t and temperature T by the following expression [7]:

$$t = \alpha(\ln\beta/T)^5$$

where $\alpha = 1.4$ and $\beta = 200$.

It was established that our data are in agreement with data [7] for pressed specimens, but not for powders (Fig. 3).

According to the corresponding literature [8] the phase composition of HTSC ceramics after its interaction with water is changed by the following scheme:

$$2YBa_2Cu_3O_{7-x} + 3H_2O \rightarrow Y_2BaCuO_5 + 3Ba(OH)_2 + 5CuO + (0.5-x)O_2$$

Thus the main results of HTSC hydrolysis are two processes: dealkalinization of barium and loss of oxygen.

It may be suggested, that the interaction of Y-Ba-Cu-O and Bi-Ba-Sr-Cu-O with water, should occur as follows: first water is sorbed at the surface of the samples and interacts with the Ba^{2+} and Sr^{2+} ions with the formation of the corresponding hydroxides. These last ones accumulate in volume and at surface and blockade their conductivity.

The obtained data correlate with those [8] and show that the Bi-containing structures are more stable to water, than the Y-containing ones, what is a significant advantage in practical investigation.

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REFERENCES

1. *M. Gurvitch.* J.Mater. Res.3, 5, 1988, 830-832.
2. *M. Yoshimoto, Barns, N. O'Bryan, et. al.* Appl. Phys. Lett., 51, 1987, 532-541.
3. *E. A[illegible]na, N. N. Oleinikov, V. I. Nefedov, A. N. Sokolov.* J. of all Uni Mendeleev Chemical Society, **34**, 4, 1989, 528-537 (Russian).
4. *A. P. Mojaev, V. I. Pershin, V. P. Shabatin.* Ibidem. **34**, 4, 1989, 504-508 (Russian).
5. *N. Meada, G. Tanaca, M. Fukutome, at al.* Jap. J. Appl. Phys. **27**, 2, 1988, 209-210.
6. *C. Chu, J. Bectold, L. Gao, et al.* Phys. Rev. Letters, **60**, 10, 1988, 941-943.
7. *Z. Dexin, X. Mingshan, Zh Zigihg.* Solid St. Com., 1988, 339-341.
8. *A. V. Stepanenko, D. S. Domanevski, at al.* Proc. of I All Union Meeting, M. 1988, 447-448(Russian).

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CHEMICAL TECHNOLOGY

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Effect of Sc Doping on Superconductive Properties of $Y_1Ba_2Cu_3O_{7-\Delta}$ Ceramics

Presented December 8, 1997

ABSTRACT. **The effect of Sc^{3+} substitution for Cu^{2+} on the superconducting behaviour of the $Y_1Ba_2Cu_3O_{7-\Delta}$ system has been investigated.**

It is observed, that small quantity of Sc doping ($x = 0.15$ and 0.30) increases the onset of the superconducting transition Tc (onset). We suggest that the substitution of Sc^{3+} at Cu (2) site incorporates the additional oxygen in the $Y_1Ba_{2-x}Sc_xO_y$ system and increases the coordination number for Cu (1) cations up to $N = 4$.

For a higher level of substitution ($x = 0.6$) the resistivity-temperature relations of the doped system begin to have semiconducting component and transition from superconductor to semiconductor occurs for $x = 1$ composition.

Key words: $Y_1Ba_2Cu_3O_{7-\Delta}$ system, Sc substitution, resistivity, superconducting transition.

The investigation of substitution of different elements for both cations and oxygen in $Y_1Ba_2Cu_3O_{7-\Delta}$ superconductors plays significant role in understanding the mechanism of superconductivity and possible technological applications of high-temperature superconductors [1].

In spite of the intensive investigation that has been made since the discovery of high Tc $Y_1Ba_2Cu_3O_{7-\Delta}$ superconductors, the effect of Sc^{3+} substitution for Cu^{2+} and Y^{3+} on the Tc has not been considered, although studies of isovalent ($Sc^{3+} \rightarrow Y^{3+}$) or heterovalent ($Sc^{3+} \rightarrow Cu^{2+}$) substitutions can lead to the important results.

Table 1 lists values of some physico-chemical parameters for both elements entered in $Y_1Ba_2Cu_3O_{7-\Delta}$ and Sc. It is clear from the table that it may be possible to obtain Sc-doped samples.

Table 1

Values of some physico-chemical parameters for both elements entered in $Y_1Ba_2Cu_3O_{7-\Delta}$ and Sc

N	Element		Ionic radii, Å				Ionization potential, ev			Electro-Negativity
		Cation	$n = 4$	$n = 5$	$n = 6$	$n = 8$	I_1	I_2	I_3	
1.	Y	Y^{3+}	-	-	0.90	1.02	6.38	12.23	20.50	1.2
2.	Ba	Ba^{2+}	-	-	1.36	1.42	5.81	10.00	-	0.9
3.	Cu	Cu^{2+}	0.62	0.65	0.73	-	7.72	20.29	-	2.0
		Cu^{3+}	-	-	0.54	-	-	-	36.83	
4.	Sc	Sc^{3+}	-	-	0.75	0.87	6.56	12.89	24.75	1.3

Sc and Y belong to the same III b group in the periodic table and Sc^{3+} ions might be expected to substitute for Y^{3+} and do not seem to affect the superconductive property. However, ionic radius of the Sc^{3+} cation is smaller than critical size of substituent cation for the formation of superconductive structure [2]. Our observations are consistent with this conclusion. Similarly, Sc^{3+} has an essentially smaller ionic radius, than Ba^{2+} (0.75Å and 1.36Å for octahedral environment, respectively) and could not be substituted for Ba^{2+}.

The investigation of the possibility of Sc^{3+} substitution for Cu^{2+} is of considerable interest, because Cu is a key element in high-Tc superconductor (HTSC) samples.

From the data presented in Table 1, we may conclude the possibility of Sc^{3+} heterovalent substitution for Cu^{2+} cations. In fact, ionic radii of Cu^{2+} and Sc^{3+} for coordination number $n = 6$ are equal to 0.73Å and 0.75Å, respectively. For coordination number $n = 5$ ionic radius of Cu^{2+} decreases and becomes equal to 0.65Å. It is expected that ionic radius of Sc^{3+} decreases in a similar way for $n = 5$ and Sc^{3+} substitutes for Cu^{2+} in Cu(2) sites (Fig.1 b,c) of HTSC unit cell (Fig. 1 a).

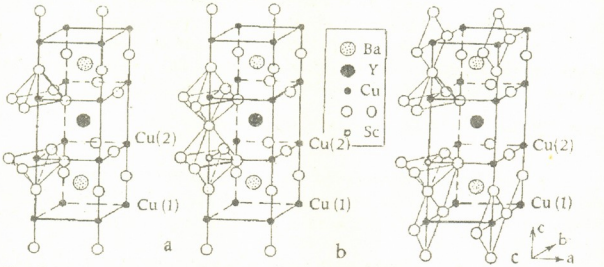

Fig.1. Possible structures of the $Y_1Ba_2Cu_{3-x}Sc_xO_y$ system

According to the above analysis, Sc^{3+} cations were substituted for Cu^{2+} in $Y_1Ba_2Cu_3O_{7-\Delta}$ ceramic samples. Different compositions of this system are given in Table 2.

Table 2

Compositions and properties of the $Y_1Ba_2Cu_{3-x}Sc_xO_y$ ceramic samples

N	Composition	X	Annealing time, h	Tc, K		ΔT, K	ρ mΩ·cm
				Onset	Zero		
1.	$Y_1Ba_2Cu_3O_{7-\Delta}$	-	23	91.7	87.2	3.9	2.78
2.	$Y_1Ba_2Cu_{2.85}Sc_{0.15}Oy$	0.15	23	93.2	83.6	4.8	6.12
3.	$Y_1Ba_2Cu_{2.70}Sc_{0.30}Oy_1$	0.30	23	92.5	81.3	6.0	17
4.	$Y_1Ba_2Cu_{2.40}Sc_{0.60}Oy_2$	0.60	23	89	-	-	40
5.	$Y_1Ba_2Cu_1Oy_3$	1.00	23	-	-	-	Semiconductor

Samples of the HTSC ceramics were prepared by standard technique. Y^{3+}, Ba^{2+}, Cu^{2+} and Sc^{3+} cations were introduced in the superconductors by conventional solid state reac-

tion: Y_2O_3, BaO_2, CuO and Sc_2O_3 powder oxides were mixed in the required proportions and sintered at 930°C in the air.

The temperature dependencies of the resistivities of synthesized samples are presented in Figs. 2-4.

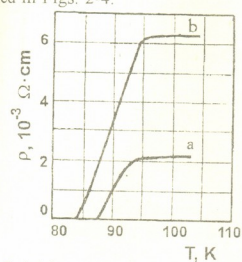

Fig.2. Resistivity as a function of temperature for $Y_1Ba_2Cu_3O_{7-\Delta}$ (a) and $Y_1Ba_2Cu_{2.85}Sc_{0.15}Oy_1$ (b) systems

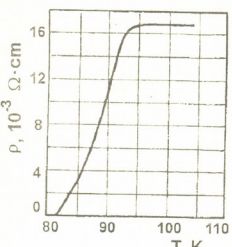

Fig.3. Resistivity as a function of temperature for $Y_1Ba_2Cu_{2.70}Sc_{0.30}Oy_1$ system

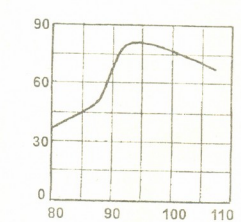

Fig.4. Resistivity as a function of temperature for $Y_1Ba_2Cu_{2.40}Sc_{0.60}Oy_2$ system

Presented curves show an increase in resistivity ρ and transition width ΔTc with increasing Sc concentration accompanied with decrease of the bulk of superconducting transition temperature Tc (zero), $\rho \to 0$, from 87.2 K to 81.3 K (for sample 1-3). For $x = 0.60$ (sample 4), the bulk of the transition Tc (zero), is below liquid nitrogen temperature.

On the other hand, it was observed, that for a low amount of Sc substitution ($x = 0.15$ and 0.30) the onset of the superconducting transition Tc (onset) increases (Tc(onset) = 93.2 K and 92.5 K respectively) when compared with the pure $Y_1Ba_2Cu_3O_{7-\Delta}$ sample (Tc (onset) = 91.7 K).

It should be noted that introduction of Sc_2O_3 in the system incorporates the additional oxygen anion. Hence, in order to clarify the effect of Sc^{3+} on the superconducting transition temperature, the samples were synthesized without annealing treatments in oxygen ($\Delta \approx 0.2$).

It should be noted that the additional 0.5 anion (-1 negative change) introduced in the system by $ScO_{1.5}$ could be transferred to the Cu cation in Cu(1) site (Cu^{2+} with coordination number 2.

In general, introduction of Sc_2O_3 in the $Y_1Ba_2Cu_3O_{7-\Delta}$ system is expected to cause two different effects: 1. Sc^{3+} cations substitute at the Cu(2) sites in such a manner (Fig. 1 b), that coordination number for Sc^{3+} is equal to 6. ($[ScO_{6/2}]$ octahedron). Due to this substitution the superconducting phase decreases and Tc depresses. 2. Cu^{2+} is replaced by

Sc^{3+} at the Cu(2) sites and coordination of Sc is pyramidal (as well as for Cu^{2+}). Under such conditions O^{-} anion (0.5 oxygen anion) is released and moves to the Cu^{2+} or Cu^{3+} cations located at the Cu(1) sites and coordination number of these cations can be increased by 0.5 and 1 for $ScO_{1.5}$ and Sc_2O_3, respectively (Fig. 1 c). Such rearrangement is possible because of higher Cu electro-negativity than for Sc.

Transition of the apical O^{-} anion from $[ScO_{6/2}]$ octahedron to the Cu^{2+} or Cu^{3+} cations located at the Cu(1) sites causes a replacement of O-Cu-O chain by triangle or square. If the coordinational number of Cu^{3+} in the oxygen-poor sample is equal to 3, the triangle will be transformed to the square due to this transition. It is clear, that under such conditions Δ will be decreased and Tc increased. On the other hand, Sc^{3+} substitution for Cu^{2+} at Cu(2) site is expected to increase resistivity ρ. Figs.2 b and 3 support this proposition. It can be seen in Figs. 2 b and 3 that onsets of the superconducting transition Tc (onset) for $x = 0.15$ and $x = 0.30$ are higher than that for pure sample ($x = 0$), although doped samples have an essentially larger resistivites than that found for pure $Y_1Ba_2Cu_3O_{7-\delta}$ sample

If Sc^{3+} content $x > 0.3$, the number of $[Cu^{3+}O_3]$ defects in system could be less than number of additionally introduced Sc^{3+} cations and each following Sc^{3+} cation at Cu(2) site is expected to be in $[ScO_{6/2}]$ octahedron. This rearrangement would not be expected to influence positively Tc. At the same time the addition of Sc induces an essential increase of the resistivity. For $x = 0.60$ the bulk of the transition Tc (zero) is below liquid nitrogen temperature.

From the evidence presented we suggest that Sc-doped system consists of two phases. Coordinational number of the Cu cation at Cu(1) sites in the "perfect phase" is equal to 4, whereas the second phase is enriched by Sc.

The resistivity-temperature relations, presented in Figs. 2 b, 3 and 4 are influenced by the content of two phases. For a low amount of Sc substitution ($x = 0.15$ and 0.30) the onset of the superconducting transition Tc (onset) increases whereas for a larger level of substitution the resistivity-temperature relations of the Sc-doped system begin to have semiconducting component and transition from superconductor to semiconducter occurs for $x = 1$.

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REFERENCES

1. *G.P.Shveikin, V.A.Gubanov, A.A.Fotiev et al.* Electronic structure and physico-chemical properties of high-Tc superconductors. M., 1990, 240 (Russian).
2. *A.M.Umarji.* Ind. J. Techn. **28**, 1990, 320-325.

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PHARMACEUTICAL CHEMISTRY

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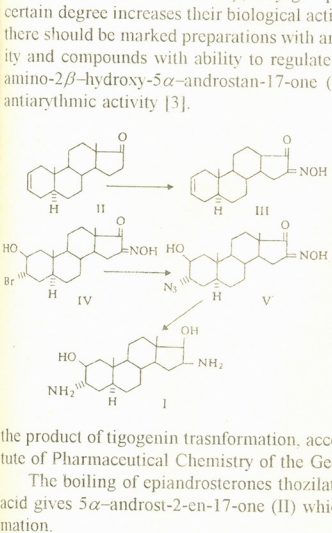
Synthesis of 3α,16β-diamino-2β,17β-dihydroxy-5α-androstanes on the Basis of Tigogenin

Presented by Academician E. Kemertelidze, December 30, 1997

ABSTRACT. **The synthesis of new derivative of 5α–androstanes series has been proposed to study its pharmacological activity.**

Key words: Steroids, 5α–androstanes, synthesis.

A great number of steroids which are spread in the nature and their synthetic analogs hormonal medicines are characterized by wide spectrum of pharmacological activity. The substitutions of amino- and hydroxy groups in the A and D rings of 5α–steroids to a certain degree increases their biological activity [1-2]. From the compounds of this group there should be marked preparations with antiarythmic, cardiotonic and hypertonic activity and compounds with ability to regulate CNS. One of them is hydrochloride of 3α–amino-2β–hydroxy-5α–androstan-17-one (ORg 6001) which is distinguished by high antiarythmic activity [3].



To satisfy strong demand for steroid preparations it is necessary to find new sources for their production.

Tigogenin, the aglycon of steroid sapogenins, was proposed as one of the best sources [4] for the synthesis of 5α–steroids by the Institute of Pharmaceutical Chemistry of the Georgian Academy of Sciences.

The aim of present work is to synthesize a new derivative of 5α–androstanes – 3α, 16β–diamino – 2β, 17β–dihydroxy-5α–androstane(I), in order to study its antiarythmic activity. To obtain this compound (I) there was used epiandrosterone actetate, which is the product of tigogenin trasnformation, according to the method worked out at the Institute of Pharmaceutical Chemistry of the Georgian Academy of Sciences [4].

The boiling of epiandrosterones thozilate with CH_3COONa in the mixture of acetic acid gives 5α–androst-2-en-17-one (II) which is the initial product for further transformation.

The existence of Δ^2-bond and 17-ketogroups in steroid ketone(II) structure makes possible various transformations. In particular, by the treatment of compound (II) with isoamyl nintrites in the presence of butilate-K in the areas of third-butanoles the 16-

Table 1

Physico-chemical properties of compounds I,III, -V

Compound N	Yield %	Solvent for crystalization Melt.p.^{0}C	Found %				Brutto formula	Calculated %				M		IR-Spectrum ν, cm^{-1}
			C	H	Br	N		C	H	Br	N	Found	Calculated	
I	62	Methanol 128-130	70.82	10.55	-	8.69	$C_{19}H_{34}N_2O_2$	70.82	10.55	-	8.70	322	322.17	3470-3210 (OH, NH_2) 1640-1625 (C-N)
III	84	Hexane 175-177	75.51	8.82	-	4.41	$C_{19}H_{27}NO_2$	75.71	8.96	-	4.46	301	301.17	3400 (OH) 1750 (C=N) 1660 (C=N)
IV	61	Dyethyl-ethere 135-137	57.32	6.85	20.22	3.49	$C_{19}H_{27}BrNO_3$	57.46	6.79	20.12	3.59	397	397.06	3570-3200 (OH) 1760 (C=O) 1670 (C=N)
V	50	Methanol 145-147	63.07	7.95	-	15.31	$C_{19}H_{29}N_4O_3$	63.18	8.02	-	15.5	361	361.16	3420-3200 (OH) 2110 (N_3) 1750 (C=0) 1640 (C=N)

oxime-5α–androst-2-en-17-diones (III) was prepared. It is known that the hydrobromination of Δ^2-bond of steroids by 1,3-dibrom-5,5-dimethylgidantoines in the presence of chloric acid in the areas of diethylethere proceeds by the transdiaxial mechanizm. This was also proved by us in the case of synthesis of 3α–brom-2β–hydroxy-5α–androstan-16, 17-diones-16-oximes(IV).

As a result of boiling of last compound (IV) with NaN_3 in areas of DMFA, the substitution of 3α–bromgroups by azidogroups occurs. Treatment of prepared substance(V) with $LiAlH_4$ in the mixture of THF proceeds with the reduction of 16-oximogroups to 16-amino group. Because of the stereo specificity of the mentioned process, it is necessary to obtain the pure product of reaction. This is achieved by the treatment of product of reaction with 3R-vinic acid.

As a result of crystallization of obtained salts from abs. ethanole and by the treatment of it with water solution of NaOH 3α, 16β–diamino-5α–androstan-2β, 17β–diole (I) was identified.

The investigation for the study of pharmacological activity of synthesized compound (I) in comparison with 3α–amino-2β–hydroxy-5α–androstan-17-ones hydrochlorides (ORg 6001) antiarythmic activity is considered to be of interest to determine the action of amino- and hydroxy substitutes position and configuration on the biological activity. The structures and composition of synthesized compounds (I-V) are determined by special analysis, i.e. IR spectrum, 'HMR-spectrum as well as mass spectrum and elemental analyses. The results of physicochemical analyses are given in Table (1;2).

Table 2

NMR-spectrum data for compounds I, III-V

Compound N	Characteristic chemical shifts (m. sh.) and constants of spin-spinic relation J (hz)
I	0.90 s.(3H,18-CH_3); 0.97 s.(3H,19-CH_3); 3.21 n. (2H,C^{16}-H and C^{17}-H); 3.03 m.(I H,C^3-H; 3.76 m. (I H,C^2-H)
III	D.79 s. (/H, 18-CH_3); 0.96 s. (3 H,19-CH_3); 2.94 qv. (2H,15-CH_2) J.hem. = 17.91 and J = 6.76); 5.60 m. (2H,C^{15}-H and C^{16}-H)
IV	0.96 s. (3H,18-CH_3), 1.05 s. (3H,19-CH_3); 2.91 qv. (2H, 15-CH_2) J.hem = 17.90 and J.vic = 6.76); 4.24 s. (IH,C^2-H), 4.34 s. (I H, C^3-H)
V	0.95 s. (3H,18-CH_3), 1.04 s. (3H, 19-CH_3),2.91 qv. (2H,C^{15}-CH_2, J hem = 17.90 and J vic = 6.76)

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REFERENCES

1. *W.R. Bucrett, F.A. Marwicr, B.B. Wargaftig.* Brit. T. Pharmacol **54**, 1, 1980.
2. *W.T. Remme, P.D. Verdouw, F.R. Hagemeyer.* Eur. T. Pharmacol. **36**, 1, 1976.
3. *M.M. Cambell, R.C. Craid, A.C. Royd, L.M. Gilbert.* T. Chem. Soc. Perkin Trans **1**, 9, 1979.
4. *N.I. Menshova, et al.* Sbornik nauchnykh trudov VNIKHFI im. S. Ordjonikidze, **10**, 1982 (Russian).
5. *T.K. Fried, E.F. Sabo.* J. Am. Chem. Soc. 79(5), 1957.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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PHARMACOCHEMISTRY

V. Mshvildadze, R. Elias, F. Delmas, G. Decanosidze, Academician E. Kemertelidze, G. Balansard

Antiprotozoal Activity of Triterpene Glycosides from *Hedera L.*

Presented April 2, 1998

ABSTRACT. **Antiprotozoal activity of triterpene glycosides isolated from the *Hedera colchica K.Koch., H.caucasigena seu H.helix L.* and *H.pastuchowii Woron.* (*Araliaceae*) leaves and fruits found in Georgia was tested on the *Trichomonas vaginalis* and *Leishmania infantum* species.**

The results indicate that the less polar triterpene glycoside fraction is more active than the medium and polar fractions.

Key words: *Araliaceae, Hedera*, triterpene glycosides, saponines, antiprotozoal activity, *Leishmania infantum, Trichomonas vaginalis.*

Species of *Hedera L.* [1] are rich in triterpene glycosides (saponines) which are derivatives of oleanolic acid and hederagenin, belonging to β–amirin group [2].

The following investigation refers to evaluation of the antiprotozoal activity of triterpene glycosides from *Hedera L.* grown in Georgia. Chemical investigation of compounds demonstrating antiprotozoal activity, elucidation of the structure-activity relationships are of definite significance for developing of highly effective antiparasitic drugs [3,4].

The fractions of triterpene glycosides of different polarities isolated from the leaves and fruits of three species of *Hedera* have been tested for their activity against the *Trichomonas vaginalis* and *Leishmania infantum*.

The fractions with the following conditional names have been studied:

1. HCL A'A -the fraction of two monodesmosides A' and A from the leaves of *H.colchica*.

hederacolchiside A': 3-0-α–L-Rhap(1→2) [β–D-Glcp(1 → 4)] -α–L-Arap- Oleanolic acid

hederacolchiside A: 3-0-α–L-Rhap(1→2)[β–D-Glcp(1 → 4)]-α–L-Arap- Hederagenin

2. HCF Cr.F - Crude fraction from the fruits of *H.colchica.*
3. HCL Cr.F - Crude fraction from the leaves of *H.colchica.*
4. HCL PF - Polar fraction from the leaves of *H.colchica.*
5. HPL Cr.F - Crude fraction from the leaves of *H.pastuchowii.*
6. HCF LPF - Less polar fraction from the fruits of *H.colchica.*
7. HCF MPF - Medium polar fraction from the fruits of *H.colchica.*
8. HCF PF - Polar fraction from the fruits of *H.colchica.*
9. HHF Cr.F - Crude fraction from the fruits of *H.helix.*

The crude fraction of triterpene saponines was obtained by the extraction with 80% methanol followed by purification with chloroform and isolation of triterpene glycosides

with buthanol.

Different polar fractions of triterpene glycosides of crude fractions were obtained by column chromatography on silicagel. The following mixtures of different polar solvents were used: chloroform-methanol 10:1 → 6:1; chloroform-methanol-water 26:14:3.

Leishmania infantum (MHOM/FR/78/LEM/ 75 strain) promastigotes were incubated at 25°C in RPMI medium supplemented with 12 % fetal calf serum, at an average density of 10^5 cells/ml. The effect of the fractions on parasite growth was measured by a range of concentrations from 200 to 0.25 μg/ml in duplicate cultures. After a 48 h incubation we evaluated the inhibitory concentration (IC50 μg/ml) by spectrophotometry at $\lambda = 560$ nm, in comparison with control cultures. IC 50 corresponded to the concentration of fraction that inhibited 50% of parasite growth. The reference compounds were α-hederin and pentamidine [5].

Trichomonas vaginalis (TVR 87 strain) were incubated at 37°C in *Trichomonas* medium (OXOID supplemented with 8% heat-in activated horse serum, at an average density of $5 \cdot 10^4$ cells/ml. The effect of the compounds on parasite growth was measured by a range of concentrations, from 500 to 0,25 μg/ml in duplicate cultures. After a 48h incubation, we evaluated the letal dose (DL 100 μg/ml) at the microscope. LD 100 is the concentration of drug that induced 100% of cell letality. A retroculture was carried out with negative cultures [5].

The reference compound was the metronidazole. The results of investigation are shown in the tables 1 and 2.

Table 1

Antiprotosoal activity of triterpene glycosides of *Hedera L.* growing in Georgia, against *Trichomonas vaginalis*

N	Fraction	DL 100 μg/ml
1	HCL A'A	=10
2	HCF Cr.F	= 25
3	HCL Cr.F	= 100
4	HCL PF	> 100
5	HPL Cr.F	> 100
6	HCF LPF	= 5
7	HCF MPF	= 10
8	HCF PF	> 100
9	HHF Cr.F	= 100
10	Metronidazol	=1

The fraction of less-polar triterpene glycosides is characterised by higher activity than the medium-polar and polar fractions. It proves once more the pronounced antiprotozoal effect of monodesmosides as compared to the bidesmosides. Therefore we expect to continue the separation and antiprotozoal activity studies of the individual triterpene glycosides from the less-polar fraction of the *H.colchica* fruits.

Table 2

Antiprotosoal activity of triterpene glycosides of *Hedera L.* grown in Georgia, against *Leishmania infantum*

N	Fraction	IC 50 μg/ml
1	HCL A'A	25 << 50
2	HCF Cr.F	250 << 500
3	HCL Cr.F	> 500
4	HCL PF	> 500
5	HPL Cr.F	> 500
6	HCF LPF	25 << 50
7	HCF MPF	50 << 100
8	HCF PF	> 500
9	HHF Cr.F	> 250
10	α-hederin	= 25
11	pentamidine	= 0,25

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REFERENCES

1. Rastitelnie resursi SSSR. Semeistvo *Rutaceae-Elaegnaceae L.* Moscow, 1988 (Russian).
2. *G.E. Dekanosidze, V.D. Mshlildadze.* Rastitelnie resursi. **29**, 2, 1993, 79-89 (Russian).
3. *J. Julien, M. Gasquet, C. Maillard, G. Balansard, P. Timon-David.* Planta Medica. 3, 1985, 185-290.
4. *B. Majester-Savornin, R. Elias, A.M. Diaz-Lanza, et al.* Planta Medica, 57, 1991, 260-262.
5. *F. Delmas, M. Gasquet, P. Timon-David, N. Madadi, P. Vanelle, A. Vaille, J. Maldonado.* Eur. J. Med. Chem. 28, 1993, 23-27.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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GEOLOGY

T. Shengelia

The Middle Eocene Volcanism of the North-Eastern Part of the Meskheti Ridge

Presented by Academician G.Zaridze, December 23, 1997

ABSTRACT. **Volcanogenic - sedimentary formation of the Middle Eocene in the eastern part of the north slope of the Meskheti ridge is divided into three suites with facies composition which completely reflects the separate stages of development of the Middle Eocene volcanism. The products of volcanism create contrasting - differentiated series of rocks, joint in the kali-basalt-trachyte formation. The volcanic process itself was mainly of the explosive character and the stages of its development were exactly connected with the development of Adjhara - Trialeti folded zone.**

Key words: Middle Eocene, volcanogenic formation, trachyte.

According to the modern scheme of geotectonic zoning of Georgia [1], the region under investigation embraces the eastern part of Chakvi - Sairme segment of Adjhara - Trialeti folded zone between the gorges of the rivers Tsablaristskali and Zvarula.

The Paleocene - Lower Eocene sediments represented by the flysh and marly facies on the territory under investigation are continued concordantly by the volcanogenic - sedimentary formation of the Middle Eocene. This last one according to the facies composition, is subdivided into several suites, that are spread regionally in the western part of the Adjhara - Trialeti zone. The oldest among them is Likani suite, composed mainly of the reiterated alternation of hornblende and olivine basalts and rarely different-clastic tuffs of dellenites, argillites, tuffargillites and tuffaleurolites.

Within the limits of Tsablaristskhali - Sakraulas interriver Likani suite (1000-1500 m) is subdivided into three suites: lower-Sairme, middle-Sakondakhi and upper-Dellenites. The first subsuite is represented by the reiterated alternation of different-clastic hornblende and olivene basaltic tuffs, with carbonate tuffargillites and argillites. Sakondakhi suite is represented by the alternation of massive, fine-clastic volcanic breccias and thick-bedded different-clastic fragments of hornblendle and olivine basaltic tuffs, with motley-coloured carbonate tuffargillites and argillites. At different levels the lavasheets (3-25m) of olivine kali-basalts, olivine-hornblende and hornblende basalts are found. Uppermost – dellenite suite is widely spread in Tsablaristskhali and Sakraula basins and is composed of dellenite sheets being in alternation with the motley-coloured pumice and ash tuffs, tuffargillites and argillites of the same composition.

Quite a different picture is met in the eastern part of the territory in Leghvana - Zvare interfluve, where thickness of Likani suite does not exceed first dozens of meters (25-65 m), and in some places it is reduced completely (environs of Vakhani village). Its facies composition is also different. In particular, besides the lavas and tuffs of dellenites, vol-

canic breccias have not been registered there either. Such a sharp change of thickness and facies is caused by the facies substitution of bedded tuffs, with the massive volcanic breccias and lavas of the Chidila suite.

In ascending section, the Likani suite is continued by the Naghvarevi suite (700-2000 m), that is mainly represented by the reiterated alternation of olivine, olivine - hornblendle and hornblende basalts and rarely massive volcanic breccias of hornblendle-leucite basanites, with motley-coloured, thin-bedded and different-clastic basaltic tuffs, tuffargillites and argillites (5-25 m). In the suite, besides the basaltoides of the above-mentioned composition, also the sheets of trachybasalts, olivine and biotite basalts, dellenites, trachytes, andesi-basalts and andesites are often met. It should be noted, that trachytes and dellenites are spread in the western part of the region (Tsablaristskhali - Sakraula interfluve), but andesi-basalts and andesites, mainly with variety of hornblendes and hornblende-biotites, are found in the eastern part (Leghvana-Zvares interfluve). The suite is widely spread on the territory under investigation and is characterized by the facies homogeneity. Exception makes only Serbaisi - Vakhani environs, where like the Likani suite, it undergoes substitution by the massive volcanic breccias and lavas of Chidila suite. The maximum thickness of the suite is registered in the western part (1800-2000 m) in the central part of the region (rivers Leghvana and Bjoliskhevi) 700-750 m; but in the eastern part the thickness is sharply reduced to 130 m (Zvarula river basin).

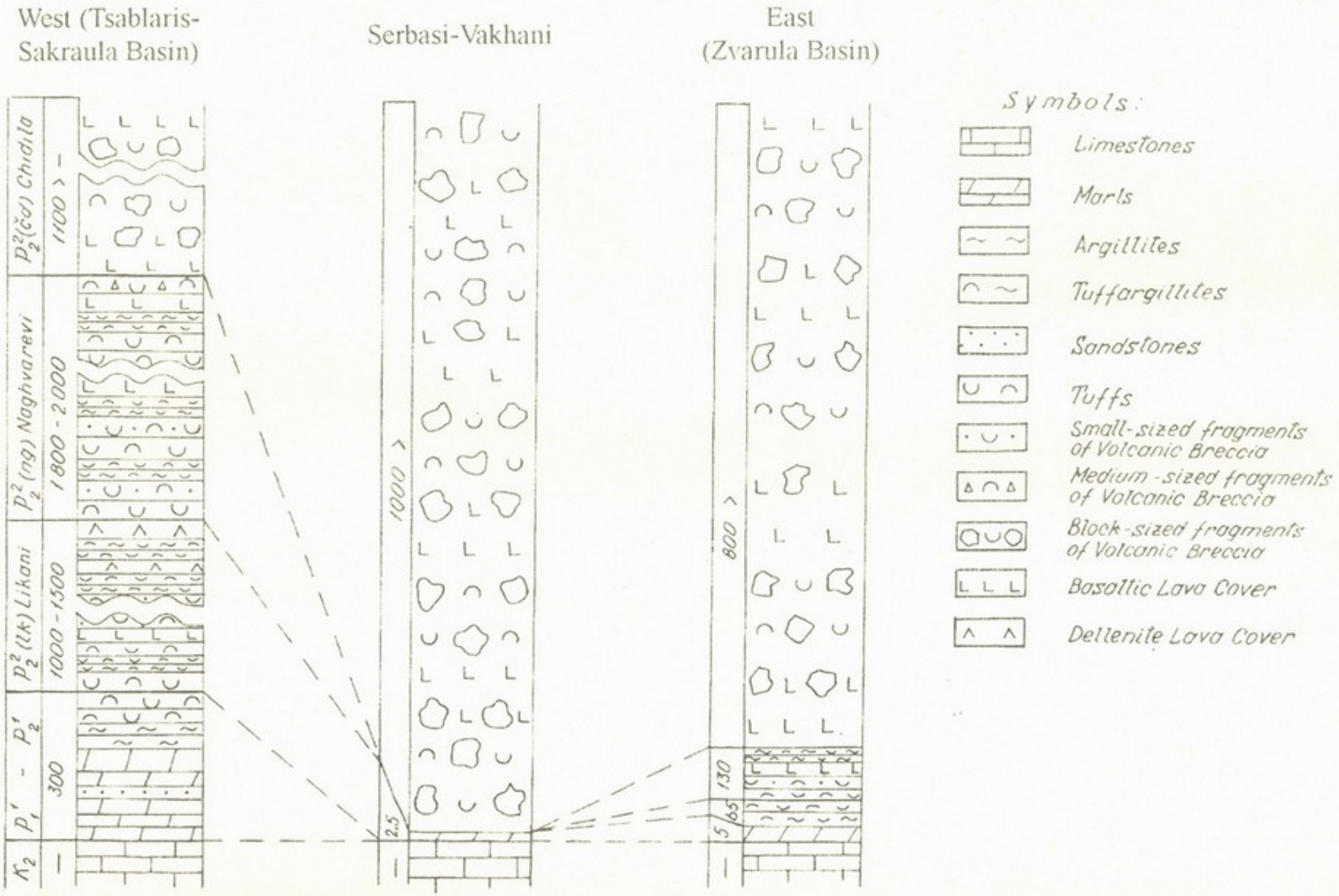
The volcanogenic - sedimentary formation has been completed by Chidila suite which is mainly spread in the comb of the Meskheti ridge (incomplete thickness is equal to 1.5 km). Besides, it is perfectly presented in the environs of villages Vakhani and Serbaisi, where it completely substitutes Likani and Naghvarevi suites (incomplete thickness equals 1 km). In the north-eastern edge (Vakhanistskhali - Zvarula interfluve) the suite reduces to 0.6-0.8 km.

The Chidila suite is facially homogeneous and is represented by the alternation of massive, often block-volcanic breccias, with lava covers; where the separate layers and thin beds of tuffs are met very rarely. Volcanic material mainly consists of olivine, olivine hornblende and hornblende basalts, though olivine-biotite basalts, olivine kali-basalts and leucite basanites also are not rare. In the suite, here and there are met segregations of hornblendites, hornblende pyroxenites, hornblende gabbro, anorthosite and quartz anorthosite, with thickness in some areas achieving - 20 cm. (e.g. Najikhura mountain).

On the territory under investigation, the volcanogenic - sedimentary formation of the Middle Eocene is mainly composed from the basaltoid rocks with dominating among them olivine varieties. There is also abundance of hornblendle basalts, where olivines are often met as accessories.

Also olivine kali-basalts and trachy-basalts are met together with the above-mentioned rocks in the western part of the region, but biotite basalts, rarely - leucite tephrites and basanites - in the eastern part of the region. Biotite analcime trachytes, trachyandesites, dellenites, very seldom - andesi-basalts and andesites are met at the different levels of formation in the basins of rivers Tsablaristskhali, Khanistskhali and Sakraula. They create contrasting - differentiated series of rocks which edge members are basaltoides and trachytes enriched with potassium, with obvious abundance of the formers (85 % and >) is registered. This association of rocks belongs to kali-basalt-trachytic formation, typical

The Lithostratigraphic Columns of the North-Eastern Part of Meskheti Ridge 1:10 000 scale



for the activized zones, with constituent rocks belonging to subalkalic potassium series (K_2O/Na_2O - 1-5.78). Among them rarely are met also the formations of calci-alkalic series (andesibasalts, andesites, some varieties of hornblende basalts) characterized by the potassium - sodium alkalinity (K_2O/Na_2O - 0.33-1.00). Besides, very seldom are met basaltoides with Na_2O obviously prevailing K_2O (K_2O/Na_2O - 0.08 - 0.24), that is conditioned by the intensive development of the superposed processes occuring in them (e.g. albitization, chlorization, zeolitization, etc).

On the territory under investigation, as well as in whole Adjhara - Trialeti zone, the development process of the Middle Eocene volcanism was characterized by the presence of stages. In particular, at the outset of the Middle Eocene, during the formation of the Likani suite, the volcanic activity was very weak and was characterized by the explosions. During the periods between explosions sedimentation of the terrigenous and hemigenous carbonates took place. At that time, sea basin bottom was characterized by indivisible and smooth relief, that was promoting both movement to far distances and homogeneous distribution of the above-mentioned material. Probably, it was the reason of homogeneity of Likani stratum suite in all region.

Initially weak volcanism gradually was intensifying together with forming of the Naghvarevi suite. At that time strong explosions, accompanied by the eruption of coarse volcaniclastics, but seldom by lava eruption, took place. During the periods of short-term quietness between the eruptions, sedimentary and volcanogenic sedimentary rocks were deposited. At the same time the sea basin bottom begins partition, caused by the origination and development of submarine volcanic construction of central type.

The Paleogene volcanism achieves maximum of its development in the upper part of the Middle Eocene and coincides with the maximum sinking of the Adjhara - Trialeti zone. At that time, the process of sedimentation, with the rare exceptions, completely suffered from the strong, sequential explosions, sometimes accompanied by lava eruptions. The prompt growth of the submarine volcanic constructions promoted the sharp partition of the basin bottom, and this, for its part, prevented from distribution and sorting of the volcanic materials. One of the central-type volcanic structure, was established as a result of analysis of the facies distribution, in the environs of the Vakhani and Serbaisi villages. In particular, only in this area of the territory under investigation, after marls of Paleocene and Lower Eocene directly follows the thick suite of massive volcanic breccias and lavas, that to the east and west undergo facies substitution by the bedded rocks of Likani and Naghvarevi suites. So, it is doubtless, that stratovolcanic-type construction had functioned from the outset of the Middle Eocene till its end and was situated in the marginal northern part of Adjhara - Trialeti zone.

The Caucasian Institute of Mineral Resources

REFERENCES

1. *I.P. Gamkrelidze.* Collective works of GIN AN SSSR. Tbilisi, 1976, 225.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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GEOLOGY

Academician I. Gamkrelidze, S. Kuloshvili

Stress Vector Orientations and Movement of the Earth's Crust of the Territory of Georgia on the Neotectonic Stage

Presented May 4, 1998

ABSTRACT. **The orientations of subhorizontal maximum compressive stress axis, established by means of regional and detailed structural analysis, recent kinematics of active faults obtained from fault plane solutions of earthquakes and results of direct measurements of the Earth's crust displacement (GPS technology) are shown. Besides the newest (neotectonic) vertical movements revealed on the basis of planation surface analysis are characterized.**

Key words: stress axis, movement of the earth's crust.

Study of the newest (neotectonic) stress conditions implies the establishment of kinematics of different scale deformation structures on the grounds of structural analysis. Character of neotectonic horizontal movement and stress conditions of the Earth's crust on the territory of Georgia have been investigated by means of detailed and regional structural analyses. In Fig. 1 the active faults and their kinematics, revealed with the help of regional structural analysis are shown. In the map the orientations of subhorizontal maximum compressive stress axis of the first order, which are revealed also by means of regional structural analysis, in particular on the basis of establishment of kinematics of different surface faults and major folds are pictured [2]. In this respect particular importance was the study to interferential (transformed) folds. On the map the orientations of subhorizontal compressive stress axis of the second order are also plotted, they are ascertained on the basis of revealing of kinematics of small-scale faults, of jointing analysis and study of minor folding. [3].

Special interest rose for recent deformation of the Earth's crust testified by present seismic activity of the region.

Recent kinematics of active faults obtained from fault-plane solutions of earthquakes (see Fig. 1) on the whole is similar to picture of paleokinematics received for neotectonic stage.

The results of direct measurements of up-to-date displacement of the Earth's crust by means of GPS technology are of a certain interest[4]. These data are very interesting in many aspects. First of all it turned out that data of direct measurement on the whole corroborate ideas about directions of horizontal movement of Earth's crust during the neotectonic stage. Though the direct measurement gives naturally more detailed and precise picture of movement. In Racha earthquake area GSP points of local network are situated. Here the points Khotevi and Sachkhere (III and IY, Fig. 1) are moving accordingly to the NE and N with the rate 2. 9 ± 2. 1 mm/year and 4. 2 ± 0. 9 mm/year. On the contrary, points Khuruti and Lesora (I and II on Fig. 1) are moving to the S and S-W with

the rate 6. 9+ 1. 1 ± mm/year and 6. 8+ 1. 2 mm/year. Therefore it is obvious that Georgian Block (Dzirula terrane) is moving to the north, whereas northward of Gagra-Java deep fault (within the Fold system of the Greater Caucasus) movement changes in the opposite direction.

That completely corroborates the opinion of continuing underthrusting of Transcaucasian plate under the Greater Caucasus[5, 6, 7]. It is interesting that E. Triep et al. came to the same conclusion [8].

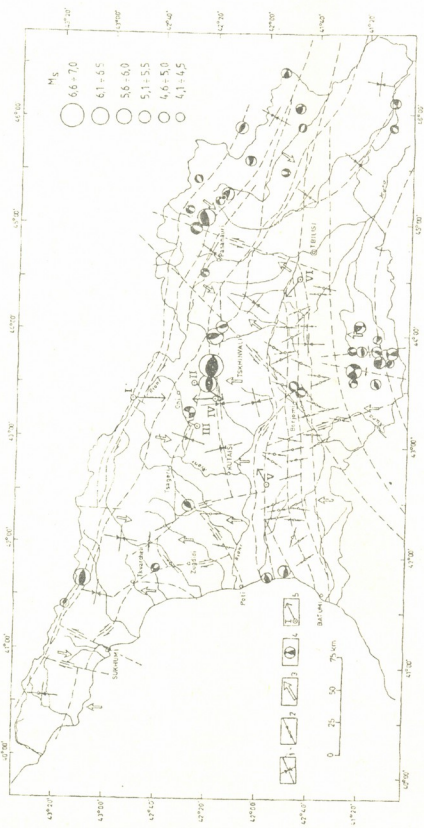

Fig. 1. Stress vector orientations and horizontal movement of the Earth's crust on the territory of Georgia (initial map was constructed in scale 1:500 000). 1-2 - The orientations of subhorizontal maximum compressive stress axis: 1-of the first order, 2-of the second order (for the western part of Dzirula terrane the data of M. Philip et al. are used[1]). 3-presumable direction of the Earth's crust motion on the neotectonic stage; 4-fault-plane solutions of earthquakes with different magnitudes (which are shown in the Fig.), lower hemisphere, compressional quadrants black; 5-directions of present motion of the Earth's crust, obtained by means of GPS technology [3]. Points of measurement: I-Khuruti, II-Lesora, III-Khoteni, IV-Sachkhere, V-Vani, VI-Nichbisi.

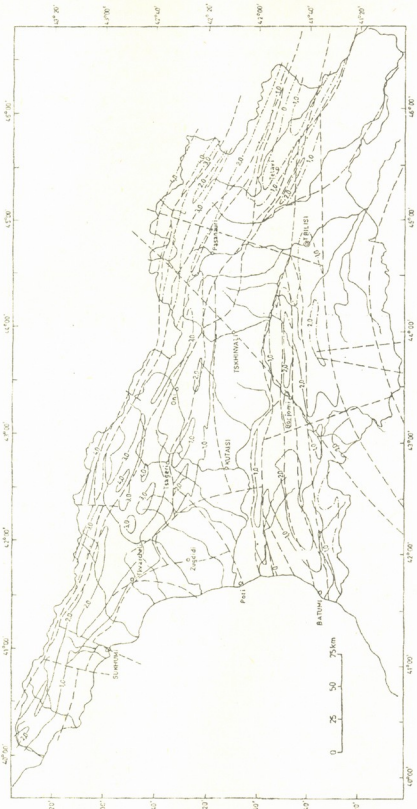

Fig. 2. Map of deformation of upper Pliocene planation surface of Georgia.

Comparatively fast northward motion of Georgian Block in its eastern part, what is conditioned by Tskhinvali-Kazbegi left lateral fault, causes here underthrusting not of Georgian Block only, but Gagra-Java zone (subterrane) too, which is completely overlapped by nappes of flysch zone. Here in the south within the Kura depression molassic cover is detached from older sediments and is shifted to the south along with the nappes of the Greater Caucasus [5].

Now about vertical movements. As is generally known the newest vertical movements can be studied by means of different structural-geomorphic methods. Here the results obtained on the basis of planation surface analysis are adduced. Erosion surfaces are developed within the Greater Caucasus and Adjara-Trialeti zone, where reconstructed united planation surface by many researchers is dated as upper Pliocene. The map of deformation of this surface (Fig. 2) exhibits the summary amplitude of vertical movements which occured since the end of Akchagil (for the last 2 mln. years). The map is

Fig. 3. Map of summary deformation of the territory of Georgia for the neotectonic stage (since upper Sarmatian).

constructed on the basis of present position of upper Pliocene (post-Akchagil) planation surface.

Analysis of planation surface deformation character exhibits arch-block nature of the newest uplift of the Greater Caucasus, which is less manifested in Adjara-Trialeti zone.

As regards the summary deformation of the region for the neotectonic stage on the whole (since Upper Sarmatian it is constructed on the basis of actual data by the definition of upper Sarmatian sole) only in depression area (Fig. 3). Whereas for the elevation area corresponding surfaces are almost not preserved in relief and that's why one has to reconstruct them by means of different methods: graphic method of completion of geological profile, calculation of denuded material volume, thickness of denudation cut etc.

Average rates of vertical movements for the neotectonic stage on the whole and for postakchagil-Quaternary period are not great and make a fraction of mm/year. They do not exceed 1-2 mm/year for the axial part of fold zones and along the faults. Rates of present vertical movements, obtained according to the data of repeated leveling, as well as for the last 10-20 thousand years by terrace analysis [9] are significantly high 3-15 mm/year. After D. Lilienberg and N. Shirinov [10] the rates of uplifting in the western part of the Greater Caucasus make 2 mm/year, in axial zone of its central part ~10-13 mm/year and exceed 15 mm/year in its east part. Axial part of Adjara-Trialeti fold zone undergoes uplifting with the rate of 2-3 mm/year. Rates of sagging are: in the central part of Rioni depression 2-4mm/year (in the vicinity of Poti -6. 5 mm/year), in its northern part 1-3 mm/year, in Kura depression -1. 5 mm/year. Superimposed Alasani depression undergoes relative sinking against the background of general uplifting of the region (6-8 mm/year) [10].

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REFERENCES

1. *H. Philip, A. Cisternas, A. Gvishiani, A. Gorshkov.* Tectonophysics, 161, 1989, 1-21
2. *I. Gamkrelidze, T. Giorgobiani.* In: H. P. Rossmanith (Editor), Mechanics of jointed and faulted rock, Balkema, Rotterdam, 1990, 183-186.
3. *I. Gamkrelidze.* Mechanism of tectonic structure formation and some general problems of tectogenesis. Tbilisi, 1976, 226 (Russian).
4. *R. Reilinger, S. McClusku, B. Souter, M. Hamburger, M. Prilepin et al.* Geophysical Research Letters, vol. 24, 14, 1997, 1815-1818.
5. *P. Gamkrelidze, I. Gamkrelidze.* Tectonic nappes of the Southern Slop of the Greater Caucasus. Tbilisi. 1977, 80. (Russian).
6. *I. Gamkrelidze.* In: Problem of the Geodynamics of the Caucasus, M. 1982, 4-8 (Russian).
7. *I. Gamkrelidze.* Tectonophysics, **196**, 1991, 385-396.
8. *E. Triep Abers, A. Lerner-Lam, V. Mishatkin et al.* Journal of Geophysical Research, **100**, 133, 1991, 4011-4033.
9. *V. Rastvorova.* The formation of mountain relief. M. , 1973, 143 (Russian).
10. *D. Lilienberg, N. Shirinov.* In : General characteristic and history of development of the Caucasus relief, M. , 1977, 45-59 (Russian).

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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PETROLOGY

Corr. Member of the Academy G.Zaridze

On the Genesis of Granitoids in Mobile Belts

Presented April 2, 1998

ABSTRACT. **Consecutive scheme of endogenic rock forming process between the antecedent basaltic volcanism and granitoids is proposed. From this scheme it follows that granite formation was preceded by basaltoide volcanism.**

Key words: magmatism, intersendental granites, ophiolites.

It is known that the majority of granitoids were formed in mobile belts, on the collision stage within the subduction zone (compression regime). They are generally preceded by basaltic submarine volcanism (tension regime) causing formation of thick volcanogenic sedimentary rock series, which H.Stille nominated as eugeosyncline, in contrast to non-volcanogenic (miogeosyncline) rock series [1]. He had generalized actual material obtained during investigations of separate regions and established a successive set magmatism in the development of eugeosynclines:

1. Initial magmatism (basaltic volcanism). In this stage emerged the rock unity, which forms the greenstone (ophiolitic) rock series (tension regime);

2. Synorogenic granitoidal magmatism (compression regime). In this stage Stille distinguished two phases: the first one corresponds with the main phase of orogenesis. During this phase appear granitoids and metamorphites conformably stratified in respect to country rocks. The second phase is late orogenic. During this phase granitoids and contact-metamorphites are unconformable (intersecting) to the bedding of host rock;

3. Postorogenic magmatism wherein Stille distinguished three phases-subsequent (andesitic), intercendental (granitic and grano-dioritic) and final (andesitic).

A set of magmatic rocks worked out by Stille were of great importance in development of all geological branches, particularly in petrology, which still hasn't lost its significance actuality.

At the same time in our opinion the terms eugeosyncline and miogeosyncline mustn't be withdrawn from usage; they should have definite place in plate tectonics.

In 1944, resulting from investigations of magmatism of Georgia, especially the Middle Jurassic volcanogenic-sedimentary suite (present name is "series") we made a scheme (set) of rock successive regular genesis which somehow specifies Stille's scheme, though at that time we didn't know his scheme [2].

Our scheme is as follows:

1. Porphyrites, diabases and gabbros (veins-channel-ways of effusive rocks)- Bajocian;

2. Volcanogenic-sedimentary porphyritic suite (series): porphyrites, diabases, etc.- Bajocian;

3. Quartzose porphyrites (v.Goliatubani) - Upper Bajocian;

4. Quartz-dioritic and quartz-gabbro-monzonitic rocks (early stage of intrusive phase) - Bathonian;

5. Granitoids (later stage of intrusive phase) - Bathonian;

6. Aplites, pegmatites and rocks abundant in silica - Bathonian.

Later on taking into account the first scheme and using all the available actual geological material obtained from different regions, a new scheme is made:

1. Early geosynclinal (submarine volcanic): mafic-ultramafic, tholeite-basalt-doleritic, basaltic-sedimentary, tuff-breccial;

2. Early orogenic (early stage of plate convergence, collision): lawsonite-glaucophane rocks (external belt of island are, active continental margins).

3. Progressive-regional metamorphites of mafic composition (crystalline schists, gneisses), granitic gneisses, plagiogranitic gneisses and migmatites (which are formed as a result of (1) rocks metamorphism), gabbro-diorite-plagiogranites, quartzose monzonites, syenites;

4. Mature orogenic (later stage of plate convergence): gabbro-diabase-granitoids (hypabyssal, subvolcanic), syenite-gabroides, granites.

From the above scheme it follows, that granite formation within the mobile belts was preceded by basaltoide volcanism (tension regime).

That successive regularity in nature of granitoids and sometimes of syenite rocks, which are connected with them, is always or almost always identified in the areas where the rocks comprising granitoid bodies (greenstone-sedimentary or more metamorphosed roks) didn't undergo erosive washing. In case of washing this regularity doesn't work. Besides relationship between granitoids and volcanogenes that contain them is not observed when granitoid bodies (massives) are tecnologically displaced, for example in overthrust zones [3].

Interrelations between granitoid genesis and their antecedent marine ("eugeosynclinal") volcanogenes of basaltoid composition were mentioned earlier by classics of geology and in 1940 this relationship was reflected in Stille's scheme.

Our scheme comparatively completely reflects endogenic rock forming process between the antecedent basaltic volcanism and granitoids. To our mind, this relationship should be taken into accont while studying granitoids.

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REFERENCES

1. *H. Stille.* Ein Fürhung in dem Bau Nordamericas, Borntragen. Berlin, 1940, 717.
2. *G.M. Zaridze.* Bull. Acad. Sci. of Georgian SSR, 5, 2, 1944, Tbilisi, (Russian).
3. *V.E. Khain.* Osnovnye problemy sovremennoi geologii. M., 1995, 188, (Russian).

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STRUCTURAL MECHANICS

Z. Madzagua

General Method of Stalks' Calculation with the Principle of Presenting the Calculation Scheme as Subschemes

Presented by Corr. Member of the Academy I. Gudushauri, December 5, 1997

ABSTRACT. **The paper shows a new method of stalk's calculation based on the principle of presenting the calculation scheme as subschemes**

Key words: combined stalk systems, statically indeterminate stalks.

It is known that by joining of stalk, flat and space elements the so-called combined constructions (systems) of different kinds are obtained. In practice combined systems the components of which are stalks (beams, arcs, ropes, etc.) are often met. In the above systems these elements are merged by means of certain ties, making a combined construction statically indeterminate system. The method shown in the present paper aims at considerable simplifying of calculation of these combined constructions. The author intends to use the method in calculation of continual constructions (shells, plates). Calculation of such constructions using classical shell's theory is usually connected with difficulties of mathematical character which are hard to be solved. By this method calculation is considerably simplified because based on the existed models (1), calculation of unbroken bodies is brought to the analogue systems of the above constructions. It must be noted that recently these difficulties have been successfully handled in Georgia due to bringing the tasks of shell's theory to integration of usual differential equations (2).

While using the calculation method shown in the paper both the stalk combined constructions and continual systems are presented by joint work of some statically indeterminate "calculation" stalks. That is why simplification of calculation of such stalks will cause the simplification of calculation of combined constructions and continual systems. This is the aim of the present paper. The essence of stalk systems is as follows.

In engineering practice any calculation is done according to loading which, as a rule, is given by different combinations of its simple components (compressed forces, compressed moments and distributed loads). It must be noted that using traditional methods of stalk's calculation it is impossible to make standardization of mathematical algorithm, because the amount of such simple loads combinations is quite large. That is why an engineer-designer has to determine main parameters (support reactions, internal force, lined and angular movements) showing stalk's tension-deformed position for each case, which is connected with some difficulties. The general method shown in the paper, based on the principle of presenting calculation scheme as subschemes for the combined system, stipulates effective handling of the above difficulties. The essence of the method is explained in what follows for the case when a vertical movement of the points shows a deformed condition of the construction.

According to the principle of independence of forces' action (so-called superposi-

tion), a calculation scheme of any statically indeterminate stalk using the mentioned method is presented by the combination of calculation schemes ("subschemes") of some proper statically determinate stalks. These schemes are possibly (virtually) the simplest from the point of view that further decomposition of each of them to subsystems is impossible. The maximal amount of fields in such subsystems is two considerably simplifying the calculation process, because standardization of determination of the above parameters that is, determination of general calculation formulae is already possible. Using such subsystems analytical equations of the parameters to each of them are derived and the parameters to be sought for the given statically indeterminate systems are presented as the algebraic sum of single-valued parameters for each subsystem. The possible variants of the simplest subsystems and analytical expressions of their calculation parameters (in particular, vertical movements), and effectiveness of the given general method in calculation of statically indeterminate stalk are given below.

In the proper case, when the calculation parameters of the given general method are vertical movements of a stalk's points, the following cases of the load of a beam on two supports serve as the simplest subsystems:

1. Beam is loaded with compressed force (Fig.1)

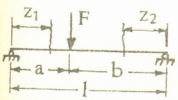

Fig. 1

$$y(z_1) = \frac{1}{EI}\frac{F \cdot b}{6 \cdot l}[z_1^3 - (l^2 - b^2)z_1],$$

$$y(z_2) = \frac{1}{EI}\frac{F \cdot a}{6 \cdot l}[z_2^3 - (l^2 - a^2)z_2]. \qquad (1)$$

2. Beam is affected by the compressed moment (Fig.2)

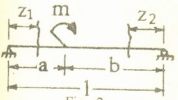

Fig. 2

$$y(z_1) = -\frac{1}{EI}\frac{m}{6 \cdot l}[z_1^3 - (l^2 - 3b^2)z_1],$$

$$y(z_2) = \frac{1}{EI}\frac{m}{6 \cdot l}[z_2^3 - (l^2 - 3a^2)z_2]. \qquad (2)$$

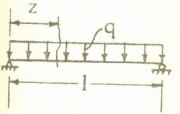

Fig. 3

3. Equally distributed load affects on the whole length of the beam (Fig.3)

$$y(z) = \frac{1}{EI}\frac{q}{24}(2lz^3 - z^4 - l^3 z). \qquad (3)$$

4. Equally distributed load affects the certain part of a beam (Fig.4)

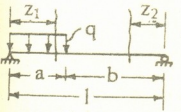

Fig. 4

$$y(z_1) = \frac{1}{EI}\frac{q}{24}\left[\left(4a - \frac{2a^2}{l}\right)z_1^3 - z_1^4 - \frac{a^2}{l}\left(a^2 + 4ab + 4b^2\right)z_1\right],$$

$$y(z_2) = \frac{1}{EI}\frac{qa^2}{24l}\left[2z_2^2 - \left(2al^2 - a^3\right)z_2\right]. \qquad (4)$$

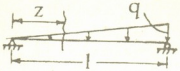

Fig. 5

5. The load, distributed according to triangle's law affects the whole length of the beam (Fig.5)

$$y(z) = \frac{1}{EI}\frac{q}{360}\left(10z^3 - \frac{3}{l}z^5 - 7l^3 z\right). \tag{5}$$

6. The load, distributed according to triangle's law affects the certain part of the beam (Fig.6)

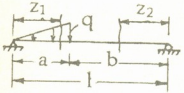

Fig. 6

$$y(z_1) = \frac{1}{EI}\frac{q}{12}\times$$

$$\times\left[\frac{al - \frac{2}{3}a^2}{l}z_1^3 - \frac{1}{10a}z_1^5 - \frac{a^2}{30l}\left(7a^2 + 35ab + 40b^2\right)z_1\right],$$

$$y(z_2) = \frac{1}{EI}\frac{qa^2}{18l}\left[z_2^3 - \left(\frac{2}{5}a^2 + 2ab + b^2\right)z_2\right]. \tag{6}$$

where formulae (1) - (6) are showing the vertical y movements in calculation points of the beam.

For determining support reactions of multiple statically indeterminate beam by forces' method, as it is known, the system of canonical equations is obtained in which for any k point the equation is as follows:

$$X_1\delta_{k1} + \ldots + X_k\delta_{kk} + \ldots + X_n\delta_{kn} + \Delta_k = 0, \tag{7}$$

where Δ_k is the vertical movement in k point caused by given load, and δ_{ki} is the same amount in the same k point caused by individual force ($X_i = 1$) in i point.

Below it is shown that calculation of the mentioned statically indeterminate beam is considerably simplified by the given general method because in this way (for example, using Mori's integral or Vereshchagin's method) to determine the movements in any concrete case it is necessary to estimate the reaction forces and bending moments in any support, the calculation of which is very time-consuming.

Below the concrete case of calculation of two-fold statically indeterminate beam (Fig.7) by the given method is considered below where equation (7)

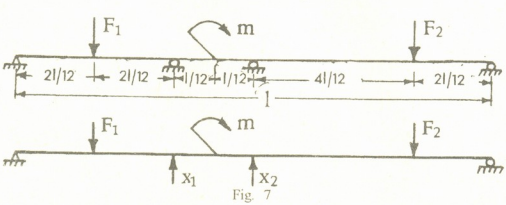

Fig. 7

for 1 and 2 points expressed in the following way:

$$\left.\begin{aligned} X_1\delta_{11} + X_2\delta_{12} + \Delta_1 = 0 \\ X_1\delta_{21} + X_2\delta_{22} + \Delta_2 = 0 \end{aligned}\right\}, \tag{8}$$

where δ_{11}, δ_{12}, ... , Δ_2 movements are determined by using formulae (1) and (2) suitable for the simplest subsystems given in schemes 1 and 2.

Vertical movements in 1 and 2 points, caused by F_1 and F_2 Forces, according to formulae (1) acquire the following values:

$$\Delta_1^{F1} = y(z_2=8l/12) = (1/EI)[F_1\cdot 2l/12)/6l]\{(8l/12)^3 - [l^2 - (2l/12)^2]\cdot 8l/12\},$$

$$\Delta_2^{F1} = y(z_2=6l/12) = (1/EI)[F_1\cdot 2l/12)/6l]\{(6l/12)^3 - [l^2 - (2l/12)^2]\cdot 6l/12\},$$

$$\Delta_1^{F2} = y(z_1=4l/12) = (1/EI)[F_2\cdot 10l/12)/6l]\{(4l/12)^3 - [l^2 - (10l/12)^2]\cdot 4l/12\},$$

$$\Delta_2^{F2} = y(z_1=6l/12) = (1/EI)[F_2\cdot 10l/12)/6l]\{(6l/12)^3 - [l^2 - (10l/12)^2]\cdot 6l/12\},$$

and the same movements in the same points, caused by m moment are determined by formulae (2):

$$\Delta_1^{m} = y(z_1=4l/12) = (-1/EI)(m/6l)\{(4l/12)^3 - [l^2 - 3(7l/12)^2]\cdot 4l/12\},$$

$$\Delta_2^{m} = y(z_1=6l/12) = (1/EI)(m/6l)\{(6l/12)^3 - [l^2 - 3(5l/12)^2]\cdot 6l/12\},$$

So Δ_1 and Δ_2 movements in 8th system get the following meanings:

$$\Delta_1 = \Delta_1^{F1} + \Delta_1^{F2} + \Delta_1^{m},$$

$$\Delta_2 = \Delta_2^{F1} + \Delta_2^{F2} + \Delta_2^{m},$$

and the vertical movements of 1 and 2 points due to $X_1 = 1$ and $X_2 = 1$ compressed forces are determined by formulae (1) in the following way:

Due to $X_1 = 1$ force

$$\delta_{11} = y(z_2=8l/12) = (1/EI)[(-1\cdot 4l/12)/6l]\{(8l/12)^3 - [l^2 - (4l/12)^2]\cdot 8l/12\},$$

$$\delta_{21} = y(z_2=6l/12) = (1/EI)[(-1\cdot 4l/12)/6l]\{(6l/12)^3 - [l^2 - (4l/12)^2]\cdot 6l/12\}.$$

due to $X_2 = 1$ force

$$\delta_{12} = y(z_1=4l/12) = (1/EI)[(-1\cdot 6l/12)/6l]\{(4l/12)^3 - [l^2 - (6l/12)^2]\cdot 4l/12\},$$

$$\delta_{22} = y(z_1=6l/12) = (1/EI)[(-1\cdot 6l/12)/6l]\{(6l/12)^3 - [l^2 - (6l/12)^2]\cdot 6l/12\}.$$

As it was expected the results of calculations by the above method are the same as those using the existed method, proving the author's suggestion that calculations in both ways are quite identical.

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REFERENCES

1. *A. Filin*. Matritsy v statice sterzhnevykh sistem i nekotorye elementy ispolzovaniya ETSVM. M-L, 1996 (Russian).

2. *I. Gudushauri*. Teoriya uprugosti v obyknovennykh differentsial'nykh uravneniyakh. Tbilisi, 1990 (Russian).

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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METALLURGY

A. Bichinashvili, M. Zviadadze, T. Mkhatrishvili, V. Achelashvili

Regulation of Microtensions within the Shape-memory Alloys

Presented by Corr. Member of the Academy G. Tsagareishvili, January 4, 1998

ABSTRACT. **In the following work the temperature subordination of regulating parameters among the inner tensions of the martensite-deformed alloys in the case of outer loading or its absence is studied theoretically. Here is calculated the thermal capacity (Dcv) on the critical temperature (Tc). On Tc temperature the regulating microtensions undergo the phase transformation of the second kind.**

Key words: regulating parameter, tension regulation, the phase transformation, the leap of thermal capacity.

The deformation within the martensite alloys cause the microtension orientaion in one direction. This latter causes effect of shape memory [1-4].

Although many authors consider the tension regulation as the main form of memory, it has not been studied theoretically until now. That is microtension orienation and its influence on the thermal and mechanic features of the deformed martensite alloys are theoretically discussed in this work.

Let us suppose that we have N tension quantity within the deformed alloys. At the same time N_1 tension is directed along the deformation axis while N_2 - in the opposite direction. In such case the regulation parameter among the tensions will be

$$L = N_1 - N_2/N. \tag{1}$$

It is obvious that L is connected with the form restoration deformation (ε), as

$$L = \varepsilon/\varepsilon_0, \tag{2}$$

where ε_0 is a previous deformation.

In the case of outer loading

$$L = \varepsilon/\varepsilon_0 \pm \varepsilon_1. \tag{3}$$

Here ε_1 is the deformation caused by the outer loading. When the outer loading increases the shape-memory then it would be "+", in other case "–".

According to Bregg-Williams theory the inner energy, which includes the tension orientation energy caused by the outer loading (σ), corresponding to the tension orientation would be

$$U = (N_{12} - N_{11} - N_{22})W - (N_1 - N_2)\varepsilon'\sigma V/N, \tag{4}$$

where N_{11} and N_{12} are pair numbers towards the deformation and opposite it correspondingly. N_{12} is a number of those pairs in which the tensions will be directed in the opposite direction. W is energy of tension interaction, ε' - quality of tetragonality, $\varepsilon = a - c/a$; a and

c are polysade parameters, N - number of tensions in V volume. As

$$N_{11} = N_1 \frac{1}{2} Z \cdot N_1/N;$$

$$N_{22} = N_2 \frac{1}{2} Z \cdot N_2/N; \tag{4}$$

$$N_{12} = N_1 \cdot Z \cdot N_2/N;$$

Considering (1) inner energy will be the following:

$$U = -ZNW/2 \cdot L^2 - \varepsilon' \sigma LV \tag{5}$$

The volume of enthropy, using the formulae of Boltsman and Stirling are:

$$S = K\ln(N!/N_1!N_2!) = K(N\ln N - N_1\ln N_1 - N_2\ln N_2).$$

From (1) we get

$$S = NK/2[(1 + L)\ln(1 + L)/2 + (1 - L)\ln(1 - L)/2].$$

Thus, the free energy will be

$$F = U - TS = ZNW/2 \cdot L^2 - \varepsilon' \sigma LN + NKT/2[(1 + L)\ln(1 + L)/2 + (1 - L)\ln(1 - L)/2)].$$

From the minimum we get

$$(\partial F/\partial L) = -[NZWL + \varepsilon' \sigma V - NKT/2 \cdot \ln(1 + L)/1 - L] = 0,$$

from which

$$L = \text{th} \cdot (ZWL + \varepsilon' \sigma V/N)KT. \tag{6}$$

When $\sigma = 0$ we have

$$L = \text{th} \cdot ZWL/KT, \tag{7}$$

by solving this we get the meaning of the critical temperature:

$$Tc = ZW/K. \tag{8}$$

Let us discuss L changing by Tc when $\sigma = 0$. In (7) and (8) we have

$$L = \text{th}(Tc/T \cdot L) \tag{9}$$

if we spread it in a raw, then $T \to Tc$, we have

$$\text{th}(Tc/T \cdot L) = Tc/T \cdot L - 1/3(Tc/T \cdot L)^3 + \ldots$$

in which

$$L = (3Tc - T/Tc)^{1/2}. \tag{10}$$

The temperature relation of the regulating (10) represents the phase transition of the second, because when $L = 0$ $\partial F/\partial L = 0$ and $\partial^2 F/\partial^2 L = 0$.

Let us discuss L change by Tc, during the outer loading. During the form restoration σ is no more than 10^4-10^5 n/m^2 but $\varepsilon' \approx 10^{-3}$-$10^{-4}$, that is why we should spread (6) in a raw and remain the first two members.

$$\text{th}(Tc/T \cdot L + \varepsilon' \sigma V/KTN) = Tc/T \cdot L + \varepsilon' \sigma V/KTN) - 1/3(Tc/T \cdot L)^3 - 1/3(\varepsilon' \sigma V/KTN)^3 + \ldots$$

as ε' and σ are small values, when $T \to Tc$ then $(\varepsilon' \sigma V/KTN)^3 \to 0$, $(Tc/T)^3 \to 1$, so we get

$$L = (3\varepsilon'\sigma V/KTcI)^{1/3}.$$

Thus, the outer loading, though not much but still causes the changing of L and correspondingly the deformation of shape restoration, which is proved by experiment.

Let us calculate the leap of thermal capacity on the critical temperature, while $\sigma = 0$ from (7) we have:

$$Cv = \partial U/\partial T = \partial U/\partial L \cdot \partial L/\partial T = -NZWL \cdot \partial L/\partial T.$$

Considering (8) and (10) we have

$$Cv = 3/2NKL(3Tc - T/Tc)^{-1/2}.$$

Finally the thermal capacity leap on the critical temperature will be

$$\Delta Cv = 3/2NK.$$

In non-deformed Mn-Cu the alloys (85 at. % Mn) at critical temperature according to [5] $Cv = 2.6NK$. Thus, in the martensite-deformed alloys the tension orientation brings additional contribution in the thermal capacity.

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REFERENCES

1. *S. P. Beljaev, V. A. Ermolaev, S. A. Kuzmin, V. A. Likhachev, V.Chupareva.*Fisika metallov i metallovedeniya. **66**, 5, 1988, 926-934 (Russian).
2. *V. N. Khachin, U. I. Paskal, V. E. Giunter and others.* Fisica metallov i metallovedeniya. **46**, 3, 1978, 511-520 (Russian).
3. *V. A. Lichachov, U. I Patrikeev, V. N. Shupletsov.* Fisica metallov i metallovedeniya. **61**, 1, 1986, 121-126 (Russian).
4. *V. N. Khachin.* Pamyat' formy. M., 1984 (Russian).
5. *J. E. Zimmerman, A. Arrot, H. Sato and S. Shinozaki.* J. Applied Physics, **35**, 3, 1964, 942-943.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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G.Gavardashvili, M.Nadaraia

Protection of Mountain Landscapes from the Erosion and Debrisflow

Presented by Academician O.Natishvili, May 5, 1998

ABSTRACT. **On the basis of carried out investigations a dependence has been obtained which permits to calculate the coefficient of slope erosion with account of time factor. A formula has been recorded, by means of which volume of the solid mass left by the debrisflow on the debris cone can be calculated.**

New constructions with high technical and economical indices have been made to protect the slopes from erosion and debrisflow.

Key words: erosion, debrisflow, debris cone, protecting constructions.

For designing the slope protecting constructions it is necessary to estimate the degree of erosion of the protecting ground by means of erosion coefficient (E). Investigations were carried out on the debrisflow(mudflow) water lines falling into the rivers Tetri Aragvi and Duruji water catchment basins.

After statistic processing series the following dependence was obtained [1]:

$$E = [0.58 + 1.40(F_1/F_0)]\cdot(t/T)^{0.21}, \qquad (1)$$

where F_1 is the erosion area of the water catchment basin of the river (km^2); F_0 is the total area of the water catchment basin of the river (km^2); t is a time interval, T is the total time of observation (30 years).

The limits of using the dependence (1) are: $0.061 \le (F_1/F_0) \le 0.24$; $0.1 \le (t/T) \le 1.0$.

According to the dependence (1) and S.Silvestrove scale [2] the degree of erosion of water catchment basins of the rivers was estimated. The results are given in the Table.

Data obtained from the river Kimbriani falling into the Tetri Aragvi river basin and the Chadistsikhis Khevi river-bed were chosen to establish the relation among the volume of the solid mass left on the debris cone after passing the debrisflow through the river-bed (W), the height of the solid mass in the analysing section (h) and the breadth of the debris cone (b).Time of investigation was 1987-1997.

Data obtained in the field are given in Fig.1 and the empiric dependence has the following form:

$$W = 966.6\ (h/b)^2 - 400(h/b) + 50.3, \qquad (2)$$

where $0 < (h/b) < 0.5$.

New constructions for protecting the mountain landscapes from erosion and debrisflow processes have been made, the know-how of which is certified by the corresponding certificate [3,4]. Erosion-preventive structure for mountain lanscapes consists of polyethylene sacks filled with local ground (Fig.2). They are fixed to the ground surface with metal fasteners. On the spare parts of the slope some trees and shrubs are planted in check rows.

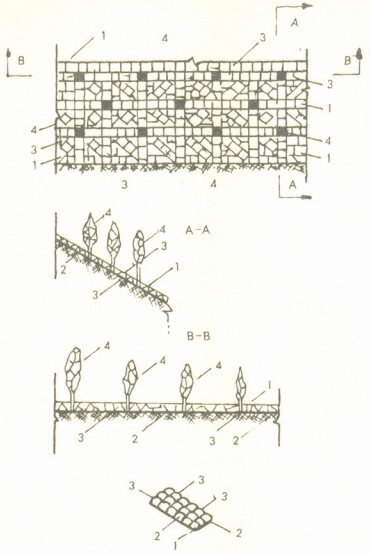

Fig.1. $W = f\left(\frac{h}{b}\right)$ dependence diagram

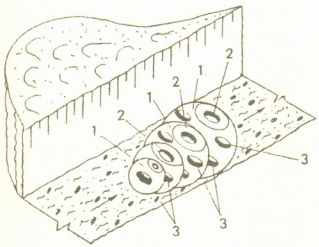

Fig.2. Erosion preventive structure

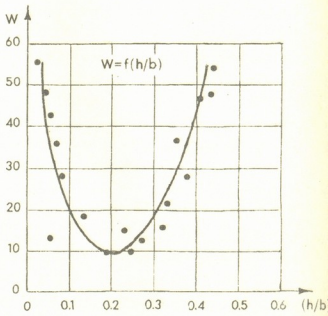

Fig.3. Debrisflow preventive structure

The structure is of a complex purpose: it protects the slope from erosion and at the same time provides the slope with green trees and shrubs.

Table

River	Value of erosion coefficient (E)				Degree of damage
	1967	1987	1995	2000	
*Chadistsikis Khevi**	0.51	0.62	0.76	0.82	medium
Chokhelt Khevi	0.58	0.73	0.83	0.97	medium
Chabarukhis Khevi	0.65	0.82	0.86	0.92	medium
Kvemo Mletis Khevi	0.71	0.91	0.99	1.25	significant
Naghvarevis Khevi	0.79	0.98	1.00	1.27	significant
Duruji	0.69	0.72	0.78	0.99	medium
Mshrali Goris Khevi	0.52	0.71	0.91	1.00	significant
Utkhovaris Khevi	0.32	0.56	0.71	0.93	medium
Nakhechis Khevi	0.12	0.40	0.80	0.88	medium
Simaghlis Khevi	0.37	0.51	0.61	0.72	medium
Salesavis Khevi	0.11	0.29	0.35	0.42	weak

*Khevi is a small river

Hollow type debrisflow(mudflow)–preventive structure (Fig.3) is a spherical form construction of high proof elastic metal with holes and a flat side. They are placed in the riverbed in the form of equilateral triangle with the vertex against the debrisflow.

For building the new constructions the second hand and inexpensive materials (polyethylene sacks, plastics, and metal fasteners) can be used, which will take over 50 % of the total volume of building materials. According to the preliminary calculation it gives economy of \$150 per m^2 for anti-erosion and over \$200 per metre (lengthwise) for debrisflow-preventive constructions.

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REFERENCES

1.*G.V.Gavardashvili.* The new mud-protective structures and their calculation methodology. Tbilisi,1995
2.Aerophoto geodezicheskie izyskaniya v selskom khozyaistve.M.,1980 (Russian)
3.*G.V.Gavardashvili, R.L.Sharangiya.* Ustroistvo dlya borby s eroziei. A.C. N1783042. Bull. N47, M., 1992 (Russian).
4.*G.V.Gavardashvili, M.N.Nadaraia,* et al.Mudflow Protective Structure.Georgian Patent N 582, Bull. N1, Tbilisi, 1997 (Georgian).

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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PLANT GROWING

T. Oglishvili, I. Shatirishvili, Academician T. Andronikashvili

Effect of Clinoptilolite Contaning Tuffs on the Germination of Wheat and Weed

Presented November 24, 1997

ABSTRACT. **Influence of clinoptilolite containing tuffs introduced into the soil, on the germination of wheat and weed (vetch) has been shown. Positive effect of the minerals on the qualitative and quantitative indices of agricultural plants has been established.**

Key words: clinoptilolite containing tuffs, germination, wheat, weed (vetch), qualitative, quantitative indices.

Preliminary investigations carried out on moistened filter paper in the presence of clinoptilolite containing tuff powder of Tedzami origin (Georgia) have shown that while sowing agricultural crops (wheat and barley) and the accompanying weed the 100% germination of wheat and barley was observed, while the germination of weed was suppressed [1].

The present paper deals with the study of the influence of introduction of clinoptilolite containing tuffs into the soil on the germination of wheat and weed (vetch).

Experiment was carried out in a vessel of plastic mass (4,5 l) filled with low-fertile podzol soil. One series of investigations was conducted in 4-repetitions on pure soil (absolute background). In other series of investigations 5,10,15% zeolite, clinoptilolite-containing tuffs were added, correspondingly (zeolite content in them reached 60-65%). Recurrence of the experiment was the four-times again. The soil was slightly moistened, temperature was 20-29^{0}C. Watering was natural. 50 weat and 50 vetch seeds were sown in each vessel. Germination of seeds started on the seventh day from sowing. In the vessels containing 5 and 10% zeolite, germination of seeds started two days earlier than in the vessels with pure soil (absolute background) and in the vessels containing 15% zeolite. Table 1 presents the data of the influence of clinoptilolite containing tuffs on the germination of wheat and weed.

Table 1

Germination of wheat and vetch seeds in zeolite-containing soils, %

Versions	germination of wheat	germination of vetch
1. Absolute backgroud (soil)	91	100
2. Soil, containing 5% zeolite	94	85.5
3. Soil, containing 10% zeolite	97	82.5
4. Soil, containing 15% zeolite	92	77.5

According to the obtained data the increase of the zeolite composition in the soil conditions the hindering of germination of weed (vetch) and the increase of germination capacity of grain cultures. The influence of zeolite and zeonak (1:1 mixture of zeolite and fresh poultry manure) on the growth of wheat was similar. Experiment was conducted for 10 days, in 4-repetitions. Terms of experiment were similar to those given above.

Table 2 presents a dynamics of wheat growth according to days.

Table 2

Influence of zeolite and zeonak on the wheat growth (average from the four-repetitions), cm

Versions	1	2	3	4	5	6	7	8	9	10
1. Absolute background (soil)	1.1	2.5	5.5	8.5	10.5	13.5	16.5	20.0	22.0	23.0
2. Soil + 5% zeolite	1.5	4.5	8.4	9.0	11.0	12.0	14.0	19.0	23.0	25.5
3. Soil +10% zeolite	1.2	4.0	6.0	8.4	11.0	12.0	14.5	18.0	23.0	25.0
4. Soil +15% zeolite	1.0	3.5	5.5	8.0	10.0	12.0	15.0	19.0	23.0	24.0
5. Soil + 5% zeonak	2.5	6.0	9.0	11.0	10.5	16.5	19.5	22.0	25.5	28.0
6. Soil +10% zeonak	1.8	5.9	9.0	11.0	14.0	16.5	20.0	22.5	25.0	27.6
7. Soil +15% zeonak	2.0	4.0	8.0	10.0	10.0	16.0	19.5	21.0	24.0	25.0

Issuing from the obtained results addition of zeolite and especially of zeonak to the soil, conditions the growth of wheat; the growth intensity is better observed at the beginning and at the end of the experiment. The most efficient effect of zeolite and zeonak on the growth of a plant is shown at their 5% content.

It is also shown that zeonak makes positive effect on the stability of wheat stem and its falling, similar to that in case of rice.

In Table 3 there is given an arithmetic mean increase of wheat stem height, for a ten-day period. Here again, the highest rate of the plant growth was observed during introduction of 10% zeonak into the soil.

Table 3

Influence of zeolite and zeonak introduced into the soil on the average growth of wheat height

Versions	Growth of wheat stem height, cm
1. Absolute background (soil)	1.23
2. Soil + 5% zeolite	2.67
3. Soil +10% zeolite	2.64
4. Soil +15% zeolite	2.56
5. Soil + 5% zeonak	2.83
6. Soil +10% zeonak	2.87
7. Soil + 15% zeonak	2.78

According to the data of Tables given above, zeolite and zeonak makes positive influence on the growth of green mass of wheat. The results of calculation of green mass of plant are given in Table 4.

Table 4

Influence of zeolite and zeonak contents in the soil on the growth of wheat green mass (means of 4-repetitions of tests)

Versions	Increase of green mass per ha
1. Absolute background (soil, pure)	7.4
2. Soil +5% zeolite	9.0
3. Soil +10% zeolite	8.4
4. Soil +15% zeolite	7.5
5. Soil + 5% zeonak	11.5
6. Soil +10% zeonak	10.75
7. Soil +15% zeonak	10.0

Thus, the presence of zeolite and zeonak in the soil favours germination of wheat seed, the growth of plant stem, stability to falling and the increase of green mass. The presence of the above mentioned additions in the soil hinders the process of growth of weed (vetch).

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REFERENCES

1. *T.Andronikashvili, I.Shatirishvili, M.Dokhturishvili, T.Oglishvili.* Bull. Georg. Acad. Sci. **153**, 1, 1996, 73.

SOIL SCIENCE

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Estimation of Soil Protection Properties of Agricultural Plants in Georgia

Presented by Academician Ts. Mirtskhoulava, February 25, 1998

ABSTRACT. **To study soil protection properties of agricultural plants the soil protection coefficient of agricultural plants was used. Value of soil protection coefficient of agricultural plants in Georgia depends on the pattern of agricultural lands and fluctuates from 0.40 to 0.75. Administration regions of western and eastern Georgia have low soil protection properties ("C" > 0.55). Soil protection properties of agricultural plants in Georgia changed significantly during last ten years.**

Key words: agricultural plants, soil protection coefficient, pattern of arable land, administration region, estimation.

To predict soil erosion one must know soil protection properties of the plants [1]. Factor of plants is one of the main parts of all the methods predicting soil erosion. Among them the most important is hydromechanical model created by Ts.Mirtskhoulava [2,3] in 1970-s and empirical model, the so-called USLE (Universal Soil Loss Equation). Ts. Mirtskhoulava's hydromechanical model has well grounded physical standpoint and therefore is more precise than half of the empirical models. For both types of models plants' properties of soil protection are inevitable. Plant is the most powerful factor against soil erosion.

To estimate soil protection property of agricultural plants it's better to use empirical coefficient which is determined as soil loss from plot of given plant divided by soil loss from plot of bare fellow the whole year round. For determination of coefficient of soil protection of maize and oats, the field experiments in West Georgia village Kitskhi on the soil-erosion plots of the Institute of Soil Science and Agricultural Chemistry and in village Zendidi, Institute of Tea and Subtropical Agricultural Plants were organized. The field experiment included three options: 1) bare fellow (the whole year round); 2) maize; 3)oats. Length of experimental plots was 20 m, width 5 m, inclination 8-10 degree. Humus-carbonate, heavy mechanical structure, middle washed out soil was used.

In 1986, since May 27 till October 27 there fell 550.5 mm of precipitation. Soil loss from the bare fellow plots was 137.67 t/ha, from plots of maize and oats – 50.17 and 62.17 t/ha accordingly. During the whole vegetation season soil loss was registered on the 16th, 18th, 19th and 20th of June. 332.9 mm of precipitation fell for 4 days or 60.4 % of the total precipitation, which fell during the vegetation season. Two rains, which gave 240.5 mm of precipitation, washed out 44.0 t/ha from maize plot, 34.0 t/ha from oats plot and from bare fellow plot - 79.0 t/ha of soil. In this period the soil protection coefficient of oats, for each rain changed from 0.27 to 0.45, for maize from 0.30 to 0.62. Average

annual value of soil protection coefficient was 0.36 for oats, for maize– 0.45.

Next year 1987 was very dry. In vegetation season there fell only 257.6 mm precipitation, which gave minimum quantity of surface flow in all variants of the experiment, from 26.6 – 28.9 t/ha.

In 1988, since June 6 to October 21 there fell 475.2 mm precipitation, from this amount just only 173.9 mm or 36.7 % washed out soil. Erosion activity was observed in the second part of summer, when oats were already harvested and on the surface of the soil 15 – 20 cm height stalk of oats was left. Maize produced a big amount of biomass and covered 80 – 90 % of the soil surface. After heavy shower, which continued for 3 days (August 1, 2, 3) 92.8 mm precipitation fell, soil loss from the bare fellow formed from oats (after harvest) – 5.4 t/ha. Under maize – only 1.98 t/ha. Soil protection coefficient of oats stalk formed - 0.26, of corn – 0.10. In 1988, annual soil protection coefficient for oats formed 0.21, for maize – 0.06.

Next year 1989 was as dry as 1987. In 1989 since May 25 till October 21 there fell 314.2 mm precipitation. Only third part of the mentioned precipitation affected surface run off from all the variants: from oats – 83.3 mm; from maize – 95.1 mm and from bare fellow – 99.6 mm. Soil loss in 1989 was not observed.

Soil protection coefficient of plant was determined also on mountainous part of Adjara A.R.: on the brown forest soil, on the following variants – maize, annual grass crops, lemon, wineyard, for 9 years (Table). On the experimental field in vill. Kitskhi soil protection coefficient made for maize – 0.127 (average of 4 years) and oats – 0.142. In vill. Zendidi (Adjara) average annual soil protection coefficient made – 0.186; for annual grass crops – 0.123; for lemon – 0.234; for wineyard – 0.277; for tea – 0.064. We can conclude that soil protection coefficient of agricultural plants is very dynamic index and to establish it long-term research is needed. Soil protection coefficients which are received from the simulation of rain are approximate because experimental condition and physical simulation of the rain by simulation machine is different from natural condition of field and rain. They can be used only for approximate estimation of soil protection coefficient of different plants.

Table

Soil protection coefficient of different agricultural plants
(Adjara A.R. region of Keda, vil. Zendidi)

Option	Years									Average of 9 years
	1984	1985	1986	1987	1988	1989	1990	1991	1992	
Maize (One crop)	0.160	0.293	0.296	0.180	0.115	0.147	0.152	0.186	0.148	0.186
Annual Grass Crop	0.222	0.388	-	0.040	0.096	0.062	0.056	0.135	0.104	0.123
Lemon	0.210	0.369	0.404	0.430	0.157	0.127	0.110	0.172	0.127	0.234
Wineyard	0.224	0.407	0.439	0.500	0.195	0.172	0.183	0.221	0.154	0.277
Tea	0.208	0.234	0.112	-	-	0.010	-	0.008	0.005	0.064

To study soil protection properties of agricultural plants of Georgia coefficient "C" from the method of the USLE (Universal Soil Loss Equation)was used [4-8]. Factor "C" is determined as soil loss from plot of any plant divided by soil loss from plot of bare

fellow. Using this method for administrative regions of Georgia soil protection coefficient of agricultural plants was computed. Regions, in which the difference of "C" coefficient was less than 0.05, were unified. If "C" coefficient is less than 0.45, agricultural plants had good soil protection properties. Agricultural plant, in which "C" coefficient is more than 0.55 had bad soil protection properties.

Soil protection properties of agricultural plants were determined in 1976, 1980 and 1985 according to agricultural plants structure. From 1976 till 1985 according to administrative regions of Georgia, coefficient "C" significantly changed, especially in West Georgia. In East Georgia coefficient "C" is stable and reaches relatively high values (0.55 - 0.60). Soil protection condition in 1976 was the worst and became better in 1980, especially in West Georgia. In 1985 the condition again deteriorated. Soil protection properties of agricultural plants are dynamic indexes and it depends on the planning of crops structure. For the reason that soil erosion in Georgia is high enough, crops structure is to be planned taking into consideration soil protection properties of agricultural plants.

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REFERENCES

1. *M. Kuznetsov.* Protivoerozionnaia ustoichivost pochv, M, 1981 (Russian).
2. *Ts. Mirtskhulava.* Inzhenernye metody prognozirovania vodnoi erozii, M, 1970 (Russian).
3. *Ts. Mirtskhulava.* Metodicheskie rekomendatsii po prognozu vodnoi (dozhdevoi) erozii pochv.M, 1978 (Russian).
4. *D. Mitchel, G.D. Buhenzer.* V kn.: Erozia pochv. M., 1984, 34-96 (Russian).
5. *W. Wischmeier, D.D.Smith.* Predicting rainfall erosion losses. USDA, 1978, 1-57
6. *U.Zarkova.* In: Rabota vodnykh potokov. M., 1987, 39 – 51.
7. M. *Zaslavsky.* Metodicheskie voprosy otsenki i kartografirovania erozionno-opasnykh zemel. M, 1977, 85-98 (Russian).
8. *M. Zaslavsky.* In: Erozionnoye protsesy v Sibiri. Novosibirsk, 1978. 5-32 (Russian).

FORESTRY

M.Chkareuli

Influence of Pine Cultures on Soil Properties in Kazbegi Region

Presented by Academician G.Gigauri, December 10, 1997

ABSTRACT. **This report presents the chemical analysis of soils in Kazbegi Region. The soil pit was made on the selected test plots. The analyses evidence that mineral part of soil test is formed by allite-syllital alpha clay types.**

Key words: alpha clay, sorption basis, allite-syllital-clay.

The chemical composition of soil depends on soil formation properties, on chemical mechanism and alpha clay currents. The last one is related to climatic and relief conditions of organic, residues, etc. All of them together stipulate the soil formation process [1].

The mountains and valleys represent the main soil type of researched district. Despite these soils were studied earlier and separated as a different type of soils, they have not been studied properly [2].

Thus, the aim of our research was to study chemical mechanism of forest and virgin soils in Kazbegi Region. The test plots were selected in pine artificial plantation and is aspen and birch natural stands.

The chemical composition of soil was studied in the different places: 40 years old pine cultures in Kazbegi and Gergeti and 40-60 years old cultures in Sioni and also in Gergeti virgin lands.

In Summer, 1994, the soil pits were done in the single test plots. Each above mentioned samples of material was worked out and prepared at the laboratories. The data of chemical analysis are given in Table 1.

As we see in Table 1, the accumulation of such organic substances as humus (12.2 %) was fixed on Gergeti virgin lands. On this pit the humus number reduced by profile depth, but in 55 cm depth it was 1.4%. As we think, the above mentioned is stipulated by the existence of thick grass layer, by small intensity of erosive process and by the formation of mountain grass as a number of dead organic mass. And it also should be noted that in botanical plants compositions the legumes species and among them especially shamrock take place and the last (shamrock) wholly acted on synthesis of organic substances and on accumulation of humus substances in soil.

In the other test plots, the picture of humus component distribution (of birch, pine, aspen soils) is the same as it is in the above discussed one. The „shorter" humus layer and accumulation of surface organic substances are characteristic of the above mentioned test plots.

The reaction of the soil area is acid. In virgin soils pH is in the range of 5.4-5.6. The pines of Sioni are remarkable for their extreme acid reaction, where pH is about 5 and less, which indicates synthesis of acid nature organic substances. This is also proved by C/N index. As we see in Table 1, the correlation fluctuates between 13-18 on upper part

Table 1

Whole Chemical Composition of Mountain-Forest in Kazbegi Region

Pit area S	Horizont Depth of samples ()	Humus %	N total %	N Hydrolyze mg/100g in soil	P_2O_5 total %	P_2O_5 Uptake mg/100g in soil	K_2O total %	K_2O Exchange mg/100g in soil	pH H_2O	pH KCl	Sorption Cation meof Ca	Mg	H	total	C/N
1. Kazbegi Forest	A_1 2-8	10.6	0.52	9.65	0.31	6.12	1.83	22.03	5.0	4.2	18.0	4.2	2.3	24.5	15.3
– "Elia" Pines –	B 8-35	5.4	0.41	6.42	0.19	3.16	1.71	17.25	5.4	4.6	15.2	6.3	2.4	23.9	11.2
40 years	C 35-70	1.3	0.20	-	-	2.23	1.07	5.03	5.8	4.7	8.3	7.4	1.1	16.8	8.9
2. Kazbegi Forest	A_1 2-5	7.6	0.42	12.33	0.28	5.32	1.79	32.02	5.3	4.4	20.4	5.3	1.3	27.0	14.7
– "Elia" Pines –	B 5-40	2.4	0.33	4.22	0.20	5.02	1.23	4.41	5.0	4.3	12.3	5.9	1.0	19.2	9.4
25 years															
3. Gergeti Pines –	A_1 3-6	11.2	0.41	10.30	0.28	6.43	1.62	18.80	4.8	4.0	15.6	8.3	1.7	26.6	13.2
40 years	B 6-30	2.5	0.23	8.02	0.16	1.82	0.93	2.35	5.2	4.4	13.3	8.9	1.7	23.9	8.3
4. Gergeti Birches	A_1 –10	8.9	0.39	7.66	0.19	4.82	1.40	23.87	5.0	4.2	8.4	3.3	2.2	13.9	12.3
– 40 yr	B 40-55	2.8	0.21	2.05	0.09	2.61	1.02	10.21	5.2	4.2	5.3	2.1	1.5	8.9	7.4
5. Gergeti Aspens	A_1 -10	6.6	0.30	11.02	0.32	8.22	0.88	16.74	5.2	4.0	11.3	5.3	2.0	18.6	16.1
– 40 yr	B/C 50-60	1.3	0.19	4.14	0.18	2.77	0.62	8.64	5.3	4.4	10.7	9.4	1.4	21.5	7.8
6. Gergeti virgin	A 0-3	12.2	0.63	12.69	0.29	6.62	1.91	26.18	5.5	4.8	22.3	9.4	0.71	32.4	10.3
(meadows)	B 3-14	5.2	0.38	5.30	0.14	4.70	1.46	18.63	5.4	4.4	20.7	6.3	1.0	28.0	8.7
	B/D 14-55	1.4	0.27	-	0.07	1.11	1.02	7.92	5.6	4.2	21.3	8.4	1.0	30.7	6.9
7. Sioni Pines –	A_1 3-6	9.1	0.44	8.37	0.30	3.37	1.74	24.03	4.5	4.7	16.3	5.3	2.2	23.8	18.3
60 years	B 55-65	0.8	0.21	2.19	0.06	-	1.22	9.30	4.9	4.2	14.4	7.7	1.2	23.3	11.2
8. Sioni Pines –	A_1 2-5	7.5	0.33	10.25	0.22	5.02	1.01	16.74	4.6	4.0	17.4	4.8	2.3	24.5	14.6
40 years	B 5-60	2.3	0.15	6.61	0.12	1.51	0.60	11.02	5.2	4.1	15.3	5.7	0.9	21.9	10.3
9. Sioni Birches –	A_1 –6	7.9	0.35	7.02	0.16	3.30	1.44	18.02	5.3	4.4	7.7	2.8	2.5	13	16.3
40 years	B 6-56	2.2	0.10	-	0.11	1.03	0.78	5.55	5.2	4.6	3.9	1.6	1.3	6.8	8.2

of cultural soil, but in virgin soil C/N is not more than 10.3. The least correlation of these elements about 6.9 was fixed in 14-55 cm depth of layer.

Table 2

Whole Cemical Composition of Mountain-Forest soil in Kazbegi Region

Area Pit N	Depth cm	Overheet losses %	SiO_2	Al_2O_3	Fe_3O_4	CaO	MgO	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$
1. Kazbegi Pines	2-8	23.5	63.71	19.34	8.32	0.92	1.04	5.6	21.2	4.4
	8-35	16.2	63.56	18.12	7.47	0.98	1.34	5.8	21.0	4.6
	35-70	7.4	61.36	16.07	7.03	1.07	1.66	6.4	25.5	5.1
2. Gergeti Mountain (virgin)	0-3	28.6	69.32	20.18	9.25	0.04	1.02	6.0	23.0	4.7
	3-14	19.4	67.75	18.03	8.87	1.12	1.80	6.5	22.4	5.0
	14-55	18.7	68.36	18.35	8.72	1.03	1.76	6.5	22.5	5.0
3. Gergeti Birch	1-10	19.2	61.32	20.78	7.91	1.98	1.66	5.1	25.5	4.25
	10-55	11.5	59.37	16.31	8.02	1.36	1.76	4.5	22.5	3.7
4. Gergeti Aspen	1-8	8.7	62.31	19.91	8.03	1.31	1.93	5.4	20.6	4.2
	8-60	9.3	60.56	18.02	7.82	1.42	1.07	5.8	25.0	4.7

Sorption basis sum of virgin soils fluctuates between 28-30 mg and among them calcium is the dominant (20-22 mg). These soils are unsaturated caused by maximun existence of sorption hydrogen in pines (2.3-2.4 mg).

Week emaciation of soils is fixed by the whole data of chemical composition (Table 2). SiO_2 content is high and stable in the given pits. Aluminium is 4.5 more than that of ferrum. Molecules ratio $SiO_2:R_2O_3$, changes within the range of 3.7-5. Based on it we can conclude that the mineral part of discussed soils are formed by allite-syllit alpha-clay types.

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REFERENCES

1. *G.Talakhadze, K.Mindeli.* Sakartvelos magalmtianetis niadagebi, Tbilisi,1980 (Georgian).
2. *B.Makhatadze, T.Urushadze.* Subalpiiskie lesa Kavkaza, M., 1972 (Russian).

GENETICS AND SELECTION

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Karyotypic and Sexual Segregation in Persimmon Variations

Presented by Corr.Member of the Academy D.Jokhadze, July 6, 1998

ABSTRACT. **Cultivated forms of subtropical persimmon (*Diospyros*) generate three kinds of seedlings: male, female and hermaphrodite. Their sexual locus is three allelic - a^D, a^d, a^+. Correspondingly, in case of normal meiosis female, male and hermaphrodite seedlings are generated in ratio 5:3:1. Diploid and tetraploid forms generate hexaploids, which break into initial karyotypes.**

Key words: persimmon (*Diosspyros*), karyotypic segregation.

First karyotypic study of subtropical persimmon was carried out in Japan, on the basis of which it was established that haploid number in experimental forms was 27-28 [1]. Further studies show that experimental forms of Japonic persimmon are surely tetraploid aneuploids [2].

Sexual and karyotypic evolution of Japanese persimmon is not well studied yet, therefore, present paper deals with the study of the problem [3,4].

Preliminary selected neotenic karyotypes were used as objects of observation: Chyakume (2n30,60,90), Fuiu (2n60,90), Goshogaki (2n30,60,90), Zenjimaru (2n60,90), Geili (2n60,90), Tanenashi (2n90), Tamopani (2n90), Tamopani (2n60,90), Dzhiro (2n45,90), Chinebuli (2n60,90) and Xachia (2n30,60,90). There were prepared temporary as well as permanent preparations. Temporary preparations were stained by saturated solution of acetocarmine and permanent preparations by buffer solution of ferric hematooxylin pH_3. To reduce the selection processes we used neotenic seedlings. Neotenic seedlings of persimmon begin fruit bearing even in the first year of existing, while their nomoteinic forms begin fruit bearing in the 10-12th years. From this point of view the taxons of *Aurantioideae* subfamily and *Carica papaia* are well studied [5,6].

Digital data of karyotypic segregation of neotenic seedlings are given in Table 1.

Chyakume 34000. According to the number of chromosomes all the karyotypes of this form can generate progressive as well as regressive series, namely, diploids, triploids, tetraploids, tetraploid aneuploids and hexaploids are generated from diploid form. It is characteristic of tetraploid form as well. Hexaploids generated triploids, tetraploids and hexaploids.

Fuiu 4310. The same regularity is characteristic of this variation as it was in the first case. However, hexaploid variation of this form generated only tetra- and hexaploid seedlings.

Goshogaki 1317. This form generates progressive as well as regressive series. All its three karyotypes can generate diploid, triploid, tetra- and hexaploid seedlings. In the present case aneuploids are generated by three tetraploid variations only.

Zenjimaru 3111. The tetraploid of this variation generated aneuploid seedlings, while

hexaploid generated triploids and hexaploids.

Table 1

Caryotypic segregation of persimmon neoteinic seedlings

Objects		Introduction number	Amount seeds	Karyotypes 2n 30	45	54	56	60	90	P
Chyakume	2n 30	3400	48	12	6	-	-	6	14	
	2n 60	3400	68 189	9	3	3	5	17 37	31 96	0.54
	2n 90	3400	73		17			14	51	
Fuiu	2n 60	4310	35 135	-	7	11	10		5 43	0.32
	2n 90		100	-	-	-	-	59	38	
Goshogaki	2n 30	1317	51	10	5	-	-	21	15	
	2n 60	1317	64 175	2	19	-	5	8 41	32 70	0.4
	2n 90	1317	60	4	24	-	-	12	23	
Zenjimaru	2n 60	3111	32 81	-	19	-	-	-	11 49	0.62
	2n 90		49	-	11	-	-	-	38	
Geili	2n 60	2374	73 153	21	13	-	-	13 23	26 78	0.5
	2n 90		80	5	13	-	-	10	52	
Tanenashi	2n 90	1146	31	-	-	-	-	-	31	-
Tamopani	2n 90	6411	30	-	-	-	-	-	30	-
Dzhiro	2n 60	1642	61 117	10	9	-	3	20	21 49	0.54
	2n 90		56	3	2				28	
Tamopani	2n 60	1416	56 99	23	-	-	-	23 44	23 32	0.32
	2n 90		43	-	-	-	-	21	9	
Chinebuli	2n 60	1316	100 181	13	27	-	13	21 54	39 50	0.29
	2n 90		81	17	21	-	-	33	11	
Xachia	2n 30	3575	41	13	-	-	-	15	4	
	2n 60		59 170	10	-	-	3	33 81	16 54	0.33
	2n 90		70	13				33	34	

Geili 2374. Both variations of Geili generated tri-, tetra- and hexaploid seedlings. Hexaploid generating frequency of this variation 0.5 fold exceeds the diploid and tetraploid specimen generating frequency.

Tanenashi 1146, Tamopan 6411. Both variations generate only hexaploid seedlings, they are sterile forms and the seeds are produced without impregnation (pollination).

Dzhiro 1642. Tetraploid as well as hexaploid forms of this variation generated diploid, triploid, tetra- and hexaploid seedlings. Hexaploid generating frequency of this form 0.54 fold exceeds the generating frequency of the rest of the seedlings.

Fertile Tamopani 1416. Tetraploids of this variation generated diploid seedlings, while hexaploids generated tetraploids and hexaploids.

Hexaploid generating frequency of this form 0.32 fold exceeds the tetraploid generating frequency.

Xachia 3575. All the three karyotypes of this variation can generate diploid, tetra- and hexaploids. Hexaploid generating frequency exceeds the generating frequency of all the rest of karyotypes.

Chinebuli 1316. Both variations of this form can generate diploids, tetra- and hexaploids. For its part tetra- and hexaploids break into initial karyotypes. Hexaploid generating frequency is more than that of diploid and tetraploid forms.

As it can be noted, all the karyotypes of subtropical persimmon show tendency to generate aneuploids which is not noted in other karyotypes.

Sexual breakage data are given in Table 2. The table show that variations of subtropical persimmon generate female, male and hermaphrodite specimen in ratio 5:3:1, but this

Table 2

Sexual segregation of persimmon neoteinic seedlings

Objects		Intro-duction number	Amount of seedlings in case of ratio 5:3:1									
				a^D			a^D			a^+		
			Per unit	Factual	Expec-tant	χ^2	Factual	Expec-tant	χ^2	Factual	Expec-tant	χ^2
Chyakume	2n 30											
	2n 60	3400	189	39	105	4.1	20	66	2.3	26	21	0.8
	2n 90											
Fuiu	2n 60	4310	135	65	75	8.0	25	45	2.8	21	15	2.4
	2n 90											
Goshogaki	2n 30											
	2n 60	1317	171	73	95	4.6	31	57	1.2	28	19	4.2
	2n 90											
Zenjimaru	2n 60	3111	81	36	45	2.7	41	27	7.2	13	9	1.8
	2n 90											
Geili	2n 60	2374	153	56	75	1.0	47	51	0.3	26	17	4.7
	2n 90											
Tanenashi	2n 90	1146	31	-	-	-	31	31	-	-	-	-
Tamopani	2n 90	6411	30	-	-	-	30	30	-	-	-	-
Tamopani	2n 60	1416	99	43	60	5.1	40	51	2.2	21	17	2.1
	2n 90											
Dzhiro	2n 60	1642	117	44	55	2.2	30	39	2.0	20	13	3.7
	2n 90											
Xachia	2n 30											
	2n 60	3575	171	81	95	2.1	50	57	0.9	26	19	2.5
	2n 90											
Chinebuli	2n 60	1316	180	79	100	4.4	55	60	0.4	29	20	4.1
	2n 90											

ratio is not always the same. For example, Chyacume, Goshogaki, Zenjimaru, Dzhiro, fertile Tanenashi, Xachia and Chinebuli generated female specimens less than it was theoretically expected. Similar tendency took place in generating the hermaphrodites. Their number are increased in all variations.

Data obtained permits us to conclude that karyotypical evolution of persimmon is an useful phenomenon causing the rise of vital functions of the seedlings. However, populations' ratio breakage in the process of sexual segregation is evidently directed to a new way of progressive evolution of this culture.

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REFERENCES

1. *K.Iaswi*, J.Bot. Gaz., **60**,5, 1915, 362-373.
2. *R.Sh.Goguadze, Sh.G.Sharia*. Bull. Georg. Acad.Sci., **150**, 3, 1994, 519-520 (Russian).
3. *J.Tamikawa, M.Higashi*. Bot. Mag., Tokyo, **42**, 501, 1928, 436-438.
4. *J.Tamikawa, M.Sisa, K.Asai*. Japanese Jour. Bot., **6**, 2, 1932, 139-172.
5. *I.S.Kapanadze, B.I.Kapanadze*. Ontogenez, **26**, 4, 1995, 293-299 (Russian).
6. *I.S.Kapanadze, B.I.Kapanadze*. Ontogenez, **27**, 6, 1996, 413-418 (Russian).
7. *I.S.Kapanadze, G.S.Khasaia*. Sub. cultury, 1, 1988, 136-140 (Russian).

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E. Moniava, M. Butskhrikidze, Z. Khanaeva, N. Zambakhidze

Role of Vasopressin in Organization of Long-Term Memory

Presented by Corr. Member of the Georgian Academy of Sciences V. Mosidze, November 14, 1997

ABSTRACT. **The role of vasopressin in realization of long-term memory was studied. By means of experimental study on albino rats it is clarified that lysine-vasopressin chronical administration imporves the memory and promotes preservation of the memory trace.**

Key words: behavior, bilateral escape reflexes, memory.

The latest data confirm participation of hypothalamic-hypophysial neurohormones in realization of CNS major function – memory [1-4].

Originally, the assumption about a possible role of hypophysial hormones, (especially vasopressin), in organization of memory, was stated by De Wied et al [5].

Despite certain successes, achieved in researches, accumulated actual data frequently had inconsistent character and required further specification. Till now it is not finally found out, what role can vasopressin play in organization, formation and preservation of memory at a stage of its reproduction.

The aim of this study was to find out a lysine-vasopressin role in process of consolidation, preservation and reproduction of long-term memory trace. For this we have studied the influence of small dozes of vasopressin on dynamics of conditional bilateral escape reflex elaboration.

The experiments were carried out in adult male laboratory albino rats, weighing 220-250g. For study of conditional defense reflexes the model of bilateral escape reaction was used.

The experimental cage represented a box (dimensions - 30×50×30 cm) made of transparent organic glass. The box was divided into two equal compartments by a 10 cm height partition. The floor of the cage was made from metallic rods, by means of which a threshold electrical painful stimulation was rendered to the paws. The source of a conditional signal- 60 w electric bulb- was placed in the center of the cage at height of 60 cm, which after switching on evenly illuminated the whole cage. If after presentation of a conditional signal the animal during 5 sec jumped in other compartment of the cage, the answer was considered correct and the animal fail of an electrical punishment. Otherwise it was punished by an electrical current. 20 trials were carried out in each experimental session.

During experiment the dynamics of elaboration and course of bilateral escape reaction were studied. The following indices were registered: quantity of the correct answers on a conditional signal; duration of latent period of conditional (bilateral escape reaction), and unconditional (escape) reaction. The general behavior of the animal was also observed.

For revelation of vasopressin influence on elaboration of conditional reflexes the experiments were carried out on two groups of animals. In experimental group (100 animals) for 15-20 minutes prior to the beginning of experiments vasopresin (8 Lysine-Vasopessin, "Koch-Light, England) was administered intraperitonealy (4 mg/kg). In control group (40 animals) for the similar time prior to the beginning of experiments same amount of physiological saline was administered intraperitoneal.

It is shown, that in the first day of experiment (20 couplings), the quantity of the correct answers in control group of animals reached 30 percents. In following days this parameter grew and on the seventh experimental session (in limits of 140 couplings) criterial level was reached. The indices of adequate reactions achieved 90 percents. This level was remained stable in further days also (Fig.1).

As to the experimental group of animals, they statistically significantly lagged behind control group of the animals on speed of elaboration of active escape defense reaction. In particular after administration of lysine-vasopressin, the indices of correct responses of the animals did not exceed 5 percents. In the subsequent days this parameter was gradually increased, but nevertheless much lagged behind from those at control group of the animals. The criterial level by the experimental animals was achieved only for the 10-th day (200 couplings). At further stages of experiment quantity of correct reactions of experimental and control group animals did not give any difference (Fig. 2).

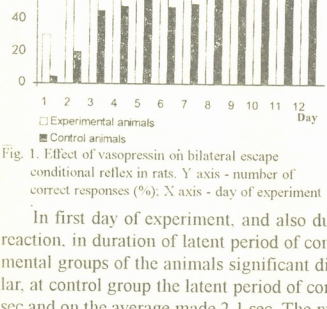

Fig. 1. Effect of vasopressin on bilateral escape conditional reflex in rats. Y axis - number of correct responses (%); X axis - day of experiment

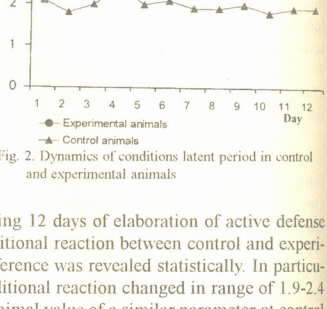

Fig. 2. Dynamics of conditions latent period in control and experimental animals

In first day of experiment, and also during 12 days of elaboration of active defense reaction, in duration of latent period of conditional reaction between control and experimental groups of the animals significant difference was revealed statistically. In particular, at control group the latent period of conditional reaction changed in range of 1.9-2.4 sec and on the average made 2.1 sec. The minimal value of a similar parameter at control group of the animals has made 2.9 sec, and maximum - 3.6 sec. In general, during all period of elaboration of conditional reaction, latent period at experimental group of the animals statistically significant exceeded those of control group of the animals (Fig. 2).

The distinction between these two groups of the animals was marked also on latent period of unconditional escape reaction. In particular, during the first 9 days of elaboration of active escape defence reaction, latent period of escape at experimental group of

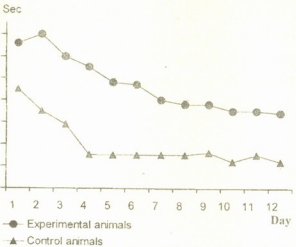

Fig. 3. Dynamics of escape reaction's latent period

animals statistically significantly exceeded those at control group. During three last days of experiments this distinction was kept, but statistically already was not significant (Fig. 3).

On the basis of experiments it was established, that for elaboration of adequate defense behavior for the animals received vasopressin, in comparison with the control animals, much more couplings (80) were required.

Proceeding from above mentioned it is possible to assume, that vasopressin interferes with formation of active defense escape reaction.

In order to study the influence of vasopressin on preservation of a conditional reflex memory trace and its reproduction control and experimental group of animals allowed to have a rest. For this period the animals of both groups were in standard household conditions and the experiments on them were not made.

The level of conditional reflex on active defensive escape was checked during three days in two weeks, 1 month and 2 months after such termination of experiment, in both control and experimental groups of animals.

Two weeks after rest the distinction in a level of reaction on conditional reflex between the control and experimental animals was not found out. However, through 1- and 2-month breaks a level of fulfillment of conditional reflex reaction at the experimental animals statistically significantly exceeded those of control group animals, in particular, on 20 conditional signals they adequately reacted 11 times (55%), and the conditional reactions were carried out on the verge of fotuity.

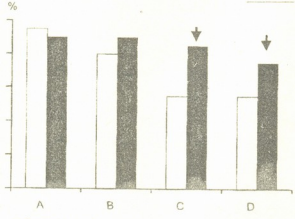

Fig. 4. Effect of vasopressin on preservation and reproduction of active escape reaction. A - before rest; B - two weeks later; C - one month later; D - two months later.

At experimental group of the animals the level of the correct answers made 80-90%. Proceeding from the above-mentioned we can conclude that the chronic 12-day administration of vasopressin promotes preservation of a trace of memory and its perfect reproduction (Fig.4).

We consider, that such influence of lysine-vasopressin on elaboration of conditional reflexes should be caused not by direct action of specified hormone on memory, but by alteration of a motivational-emotional condition of the animal. This condition in its turn finds reflection during formation of memory. The same reason was stated by Sudakov concerning to influence of vasopressin and other hypothalamic hormones on memory and processes of learning. He believes, that influence of hypothalamic neurohromone on memory and the learning is not specific and probably is caused by influence of these hormones on motivational processes [6]. According to Stephens and Logan, vasopressin alters an emo-

tional condition of the animals [4]. Concerning to role of vasopressin in preservation and reproduction of a memory trace, according to our data, it is shown that specified hormone promotes preservation of a memory trace and improves its reproduction.

The experimental data received in our study completely agree with data existing in the worldwide literature on this question [1,2,4,7-10].

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REFERENCES

1. *B. Alescio, Romane., B. Soumiren-Mourat.* Behav. Brain Res. **16**, N2-3, 1985, 185-237.
2. *J. S. Jenkins, S. S. Nussey.* Clin Endocrinol., **34**, 6, 1991, 515-525.
3. *E. Moniava, G. Vadachkoria et al.* Bull. Georg. Acad. Sci. **132**, 3, 1988, 617-620.
4. *L. R. Stephens, S. D. Logan.* J. Neurochem., **46**, 1990, 640-651.
5. *D. De Wied.* In: Ganong W., Martini L. "Frontiers in Neuroendocrinology 2. 97-146. Oxford Storypress, London (New York), 1969.
6. *S. Sudakov.* J. VND, **37**, 1, 1987, 1610-1613.
7. *D. De Wied, H. M. Cereven, S. Landle, A. Witter.* J. Pharmacol., 1972, 1118-1122.
8. *D. De Wield, O. J. W. Graffori, J. P. H. Burbach, G. L. Kovacs,* J. M. Van Ree. J. Pharmacol., Exp. Ther., **241**, 1987, 268-274.
9. *G. L. Kovacs, D. H. G. Versteeg, E. R. De Kloet.* Life Sci., **28**, 1981, 1109-1116.
10. *H. Schuls, G. L. Kovacs, G. Telegdy.* Acta Physiol. Hung., **45**, 1974, 211-215.

HUMAN AND ANIMAL PHYSIOLOGY

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Nonlinear Analysis of Electrophysiological Activity of Normal Heart

Presented by Academician T. Oniani, October 23, 1997

ABSTRACT. **The role of modern tools of nonlinear dynamic theory, as method for experimental and even clinical investigations in cardiology is well known. At the same time it is not clear if nonlinear characteristics of ECG relate immediately to the dynamics of electrophysiological processes in the heart.**

The aim of present study is quantitative and qualitative evaluation of dynamical processes in normal human heart, using tools of nonlinear analysis for numerical ECG. Moreover, we evaluate influence, not related with myocardial processes, nonlowdimensional and additive noises on dynamics of ECG. We argue, that dynamics of electrophysiological activity of normal heart is a lowdimensional nonlinear processes with fractal dimension 2.8.

Key words: nonlinear dynamics, electrocardiogram, phase space, lowdimensional attractor.

For the last decade the study of complexity, or more general nonlinearity of real world processes is one of the most exciting and fastest growing branches of nowadays science [1-5]. Wide range of complex multivariable processes ranging from the study of behavior of the weather to the analysis of biological and medical phenomena is investigated by nonlinear dynamics or the so-called "chaos theory". H.Poincare was the first who pointed out that complex of nonlinearity "randomness" is global property of natural processes and is not always related to the presence of many degrees of freedom [4], and is caused by inherent properties of natural processes.

Since 80-s practical tools of nonlinear dynamics were developed [6]. They were used for quantitative evaluation of different real processes in human organism so that as J.Gleick puts it "the human body may well be the paragon of a complex dynamical system and chaos theory makes possible a new kind of physiology" [5]. From this point of view investigation of dynamical aspects of processes in normal and pathological heart is of special interest [7-12].

For the last years in scientific literature it was shown that the dynamics of the electrophysiological activity of heart is not irregular, fully aperiodic process i.e. belongs to the so-called deterministic chaos with fractal dimention 2.9-6.1 [10,12]. At the same time the problem whether chaos is physiological, is far from solution. In other words it is not clear whether variability of ECG reflects intrinsic heart activity or are due to dynamical additive noise presented in every real system. It is no doubt that this is very important for the understanding of cardiac dynamics. For solving such problems we use the so-called sur-

rogate time series methods, computing dynamical properties of original and "shuffled" time series, for rejecting null hypothesis about absence of deterministic structure in ECG.

In this study we investigate standard ECG records of normal human belly.

The signal is digitized at regular time intervals such as to obtain desired (N) length time series (for our conditions N = 16000 data points). Sampling frequency of 250 Hz with 12 bit resolution. It was used nonrecursive digital filter. Using digitized ECG, as scalar time series $\{X_i\}$, $i = 1, 2, 3, \ldots, N$ it was reconstructed phase space of considered process. Embedding manifold of time series is reconstructed by means of the delay methods [6,13]. Exactly for given time series it was reconstructed a set of m-dimensional X_j vectors in R^N i.e.

$$\begin{aligned} X_1 &= \{x_1, x_{1+\tau}, \ldots, x_{1+(m-1)\tau}\}, \\ X_2 &= \{x_2, x_{2+\tau}, \ldots, x_{2+(m-1)\tau}\}, \\ &\ldots\ldots\ldots\ldots \\ &\ldots\ldots\ldots\ldots \\ X_{N^*} &= \{x_{N^*}, x_{N^*+\tau}, \ldots, x_N\}, \end{aligned} \tag{1}$$

where $N^* = N - (m - 1)\tau$ stands for the number of phase points on the attractive manifold, τ is delay time should be chosen the first zero crossing of autocorrelation function of the data [6], m - corresponds to embedding dimension [3,6,14]. After reconstruction of phase portrait the main task of nonlinear methods is quantitative and qualitative evaluation of attractor [6,14]. In present study nonlinear analysis of ECG includes the following steps:

1. Calculation of power spectrum is a well known qualitative test for differentiation between regular and irregular processes but it doesn't distinguish low dimensional chaos from white noise [4].

2. Calculation of autocorrelation function. Autocorrelation function also qualitatively detects existence of aperriodic dynamics, represents the average value of the product of a signal in a given instant and its value τ - time later, i.e. this function measures the correlation between two points separated by a lag - τ.

3. Other qualitative tests, first return map next maximum map, 2 and 3 dimensional phase portraits, are concerned with phase space structure and are valid instrument for studying the stable properties of system because they encapsulates dynamical properties considered processes.

4. For quantitative evaluation of dynamics of normal heart electrophysiological activity we used Grassberger-Procaccia correlation integral calculation method:

$$C(r) = \lim_{N\to\infty} \frac{1}{N^2} \sum_{i,j=1}^{N} H\left(r - \left\|X_i - X_j\right\|\right) \tag{2}$$

for different, m-dimensional phase space [6,15-17]

$$d_2 = \lim_{r\to 0} \log C(r) / \log r \tag{3}$$

d_2 is the so-called correlation dimension.

5. Next, very important measure of a systems dynamics is the spectrum of character-

istic Lyapunov exponents, which completely describes the characteristics of the trajectories in phase space. In this study we evaluated only maximal Lyapunov exponent using the algorithm developed by Sato et al. [6,14,18]. We have tested our implementation of algorithm by analyzing time series from mathematical systems with known attractors (Hennon and Lorenz equations) and obtained already tabulated values for correlation dimension and Largest Lyapunov exponents [4,6].

6. To avoid corruption of investigated dynamics by noise and filtration we undertake shuffling of original data series using random number standard generator [15,16].

As it was mentioned above, the main goal of present study whether calculated by GPA fractal dimension, reflects real dynamics of electrophysiological activity of normal heart. We used modifiing method of surrogate data set generator which allows randomization of considered time series sequence. Our investigation shows that qualitative characterization of surrogate sequence: power spectrum, autocorrelation function, first return and maximum maps indicated quite different picture for surrogate series in comparision with original data set (Figs.1 and 2 a,b,c). Phase portraits for original and surrogate data also reflect clear qualitative difference (Fig.1.d and Fig.2.d).

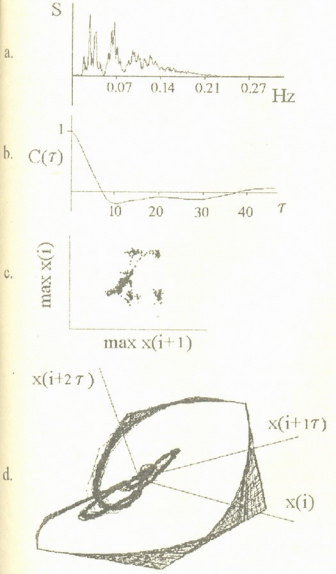

Fig.1. Power spectrum (a), autocorrelation function (b), next maxima map (d), and 3 dimensional phase portrait (c) of original ECG.

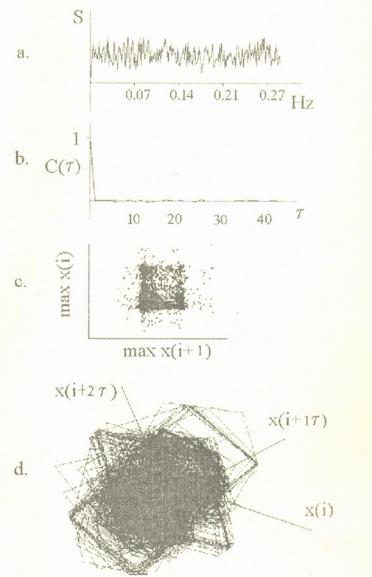

Fig.2. Power spectrum (a), autocorrelation function (b), next maximums map (d), and 3 dimensional phase portrait (c) of surrogate data.

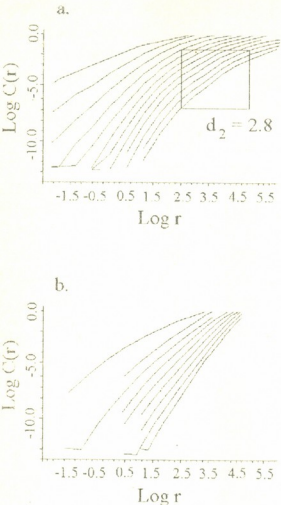

Fig.3. Log $C(r)$/Log r plots of ECG (a) and surrogate data (b) respective.

Quantitative analysis using GPA (Fig 3 a,b) shows that slope of linear part of correlation integral of ECG as time series, reaches limit value faster then for surrogate time series. It is important that slope of correlation integral for sequence of random numbers in a ECG-s range, raises unlimitedly by increasing of embedding dimension (Fig 3 d). In the same time for the same radiir in phase space ECG is characterized higher $C(r)$ value than for surrogates. This last one, together wih lower value of Lyapunov maximal coeficients (0.06+0.007 and 0.13+0.02 respectively) indicate chaotic determinism of investigated processes [4]. In general nonlinear character of heart electrophysiological activity is undoubt [6-12] but problem is the value of their exact dimension. This question is under discussion. In the literature available for us mentioned values are quite different (for example for normal heart ranges from 2.9- to 6.1) [8,12]. Our investigation shows that dynamics of electrophysiological activity of normal heart is not distored by noise effects and represents low dimensional nonlinear process with dimension 2.8. This value is near to lower limit of value given in literature and is quite logical for nearly quasiperiodic processes.

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REFERENCES

1. *B.Mandelbrot.* The Fractal Geometry of Nature. W.H.Freeman Co.New York. 1983.
2. *C.Marshal.* Predictability, stability and chaos. Ed. A.Roy.1991.
3. *D.Crutchfield., D.Farmer., V.Packard.* Sci.Am., 255, 6, 1986, 16-30.
4. *P.Berge, Y.Pomeau, C.Vidal,* Order in chaos. New York. 1988.
5. *J.Gleick.* Chaos making a new science. Viking Penguin Inc., NY. 1987.
6. *H.Abarbanel.* Rev.Mon.Pnyz. 65, 4, 1993,1331-1392.
7. *J.M.Scinner, A.L.Goldberger, G.mayer-Kress, R.E.Ideker.* Byotechnology, 8, 10, 1990, 11.
8. *T.Elbert, W.Ray.* Physiol.Rev. 74, 5, 1994, 1-50.
9. *L.Glass, P.Hunter.* Physica, D43,1990,1-16.
10. *R.Eberhart.* IEEE Engineering in medicine and biology. 10, 3. 1993, 34-35.
11. *J.J.Zebrowski, I.Poplawski.* Phys. Rev. E. 50, 5, 1994, 234-248.
12. *A.Babloiantz, S.Destexe.* Biol.Cybernetics. 58. 6, 1988, 203-211.
13. *F.Takens.* In:Lecture notes in mathematics, Eds. B.L.Braaksma., H.W.Broer., F.Takens (Spring,Berlin,1985) 99-106.
14. *J.Eckmann, D.Ruelle.* Rev.Mod.Phys., 57, 1, 1985, 617-655.
15. *J.Theiler.* Phyz. Lett.A. 196, 5-6, 1995, 59-66.
16. *D.Prichard, J.Theiler.* Phys.Rev.Lett.,73,7,1994,6.
17. *P.Grassberger, I.Procaccia.* Phys.Rev.Lett., 50, 2, 1983, 346.
18. *S.Sato, M.Sano, Y.Savada.* Progs. Theor. Phys., 77, 1, 1987, 1.
19. *G.Mayer-Kress.* In:Directions in chaos.Ed. Hao Bai-Lin, 1987.

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BIOCHEMISTRY

M. Tabagari, L. Kutateladze, L. Kvachadze

The Selection of Producers of Amylases

Presented by Academician G.Kvesitadze, November 27, 1997

ABSTRACT. **Strains, representatives of mycelial fungi, active producers of regular α–amylase - *Aspergillus oryzae* 3-9-15, acid-stable α–amylase - *Aspergillus niger* 147-A and glucoamylase - *Aspergillus awamori L*-56 have been chosen. The different sources of carbon, nitrogen, phosphorus and vitamins have been tested on *Aspergillus awamori* L-56 glucoamylase biosynthesis under the conditions of deep cultivation. The optimal composition of the medium have been chosen.**

Key words: α-amylase, glucoamylase, biosynthesis, medium, carbon source, nitrogen source, phosphorus source, vitamins.

Amylases are one of the most spread enzyme groups in the nature. Among them α–amylase, glucoamylase and β–amylase are of great interest. α–amylase acts on starch, glycogen and likewise chemical structural oligo- and polysaccharides, resulting in the mixture of maltose, glucose and maltotriose [1]. α–amylase is often met in bacteria [2-6] and in microscopic fungi [7-9], especially in *Aspergillus* genera. While the cultivation of the indicated fungi, two forms of α–amylase were found - regular and acid stable. Glucoamylase decomposes as high molecular polysaccharides as well as low molecular sugars to glucose. Glucoamylase in microorganisms is met in microscopic fungi of *Aspergillus* and *Mucor* genera and yeasts of *Endomicopsis* genus [10]. β–amylase hydrolytically decomposes starch, glycogen and their related poly- and oligosaccharides to maltose. It is often met in plants and seldom in microorganisms.

Amylases are effectively used in production of alcohol and beer, in bakery industry, in production of high quality white paper, in medicine to cure glycogenase diseases [11].

The goal of the present work was to choose an active producers of regular and acid α–amylases and glucoamylase and to optimize the cultivation conditions.

The search of amylase producers in the collection of microorganisms of microscopic fungi was carried out at the Institute of Plant Biochemistry of the Georgian Academy of Sciences. While the investigation, the fungi were grown on modified, liquid Minoda-Tsukamoto medium [12], regular α–amylase producer - *Aspergillus oryzae* 3-9-15 - in Chapek modified medium [13]; acid stable α–amylase producer - *Aspergillus niger* 147-A - in modified Chapek medium [14]; glucoamylase producer - *Aspergillus awamori* L-56 was grown in the modified Chapek medium of the following composition (%): starch - 6.0; $NaNO_3$ - 0.9; KH_2PO_4 - 0.1; $MgSO_4 \cdot 7H_2O$ - 0.05; $FeSO_4$ - 0.0002; malt spout - 3.0.

The suspension of the grown culture conidi was used as sowing material on beer sweet 7^0B solid medium during 10 days at 30^0C. The deep cultivation of fungi was carried out in 750 ml Erlenmeyer flasks in 100 ml medium on the shaker (200 g/min) during 72

hours: *A.oryzae* 3-9-15 and *A.niger* 147-A were grown at 30°C, but *A.awamori* L-56-at 35°C.

Amylase activity was measured according to the known method in cultural liquid filtrate [14]. The amylase active producers were sought in the genera of microscopic fungi: *Mucor, Rhizopus, Aspergillus, Penicillium, Trichoderma, Alternaria, Fusarium* and in the line of *Mycelia sterilia*.

The data obtained after the investigation were the similar to the data from the literature concerning the amylase producers in microscopic fungi which are often met in *Astergillus* genera. It should be mentioned that the regular α–amylase is met in green-yellow *Aspergilles*, but acid-stable α–amylase and glucoamylase in black *Aspergilles*. The most active producer of the regular α–amylase is *A.oryzae* 3-9-15, A.niger 147-A is the active producer of the acid stable α–amylase; and *A.awamori* L–56 is the active producer of glucoamylase (Table 1).

Table 1

The activities of acid-stable and regular α–amylases and glucoamylase of chosen strains

Activity, U/ml			
Strain	Acid-stable α-amylase	Regular α-amylase	Glucoamylase
A.niger 147-A	1.7	0.8	12
A.awamori L-56	trace	1.3	75
A.oryzae 3-9-15	trace	13.2	1.4

As at the beginning of our work optimal media of *A.niger* 147-A and *A.oryzae* 3-9-15 were known, the purpose of our investigation became to carry out optimization of *A.awamori* L-56 culture medium to increase glucoamylase biosynthesis. Starch 6 %, wheat bran, substances with different types of glycoside bonds and some monosaccharides were tested to choose carbon source in culture medium. In particular glucose, galactose, arabinose, ramnose, xylose, sorbite, mannitole, maltose, sucrose, lactose, cellobiose (according to 0.8% cabron). The highest activity of glucoamylase was marked in the medium at the presence of the starch and maltose (Table 2).

Further, in order to study the character of glucoamylase biosynthesis, glycerol according to 0.8 % carbon was introduced into medium as a carbon source, and after 24 hours, starch of various concentration, maltose and glycerol were added to each flask. The highest glucoamylase activity was obtained by the adding of starch at initial amount. In the case when the content of starch exceeds 6 %, relatively low glucoamylase activity was marked that could be explained for the glucose obtained in cultural liquid has the role of catabolic repressor. To study the influence of nitrogen on glucoamylase biosynthesis by *A.awamori* L-56 we used organic and inorganic sources. The highest activity was obtained while using sodium nitrate. Urea appeared to be the best among nitrogen organic sources (Table 3).

In addition the influence of each amino acid on glucoamylase biosynthesis by *A.awamori* L-56 has been studied. In the presence of lysine in culture medium the increase of glucoamylase activity was marked. Then, the influence of amino acids on glucoamylase

biosynthesis by the chosen strain in the absence of malt sprouts was studied. As a result glucoamylase activity was reduced. This could be explained by the fact that the malt sprouts, as is known, contain the whole complex of aminoacids [12] that provides glucoamylase increased activity.

Table 2

The influence of different sources of carbon on biosynthesis of glucoamylase of *Aspergillus awamori* L-56

Carbon source	Glucoamylase activity, U/ml
Glucose	36
Galactose	34
Arabinose	24
Xylose	27
Sorbite	28
Mannitole	34
Maltose	69
Sucrose	34
Lactose	38
Cellobiose	24

Table 3

The influence of different nitrogen sources on biosynthesis of glucoamylase of *A.awamori* L-56

Nitrogen source	Glucoamylase activity, U/ml
$NaNO_3$	75
KNO_3	57
NH_4NO_3	57
$(NH_4)_2SO_4$	46
NH_4Cl	53
$(NH_4)_2HPO_4$	67
Urea	60
Yeast extract	
1.0%	57
1.5%	53
3.0%	44

To identify effective phosphorus source, single and double substituted potassium and double substituted sodium and ammonia phosphates were used. The above mentioned phosphates were brought into the medium, where carbone source was starch, and nitrogen source-sodium nitrate in amount of 0.45 % by phosphorus. The maximal accumulation of glucoamylase was marked in the presence of double substituted ammonia phosphate. Various sterilyzed vitamins - thiamine, nicotine acid, biotin, pyridoxine, adenosine, ascorbic

acid, rutin were introduced into culture medium at concentrations 0.0005; 0.005 and 0.05 μg/ml. The vitamins did not influence glucoamylase biosynthesis. A little increase of the initial activity was marked only by the use of 0.05 μg/ml amount of biotin. Biostimulator - the product of thermophilic metan fermentation was introduced into the culture medium in the further experiments. This biostimulator is used in cattle breeding as a source of vitamin B_{12}. In some cases instead of the biostimulator its acid hydrolizate was used. The ability and content of the indicated preparation are discussed in a number of publications [15,16]. Acid hydrolyzate was added in amount of 1-4 ml to 100 ml cultural medium, and the preparation itself - 0.450 mg/100ml. The use of the indicated preparation did not cause the increase of glucoamylase activity. Hence, on the basis of the data it can be concluded that the strain has the ordered vitamin change.

Thus, as a result of the conducted work, active producers of regular and acid stable α-amylases and glucoamylase – *A.oryzae* -3-9-15, *A.niger* 147 -A and *A.awamori* L-56, respectively have been chosen.

The optimal composition of cultural medium (%): starch - 6.0; $NaNO_3$ -0.91; $(NH_4)_2HP_4$ - 0.085; $MgSO_4 \cdot 7H_2O$ - 0.05; KCl - 0.05; $FeSO_4$ - 0.0002; malt sprout - 3.0 has been stated for the cultivation of *A.awamori* L-56 -the glucoamylase producer.

In case of necessity, glucoamylase production can be increased by 14 % while using lysine in the medium, but it should be mentioned that the price of glucoamylase preparation can be increased in this case.

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REFERENCES

1. *G.I. Kvesitadze.* Gribnye i bacterialnye amilazy. Tbilisi, 1984, 154 (Russian).
2. *K.H. Meyer, M. Fuld, P. Berfeld.* Experientia, 3, 411, 1947.
3. *K. Ogasahara, A.Imanischi, T.Isemura.* S. Biochem, Tokyo, (B), 67, 1970, 83.
4. *N.E. Welker, I.I. Campbell.* Biochemistry, 6, 1967, 3681.
5. *K.H. Otrup.* Denmark Datent, 123726, 1972.
6. *U. Mukhtar, Rao M.V. K.* Indian S. Microbiol. **12**, 1, 1972.
7. *R.V. Feniksova.* Candidate theses. VNIISP. M., 1956 (Russian).
8. *G.I. Kvesitadze, L.L. Kvachadze, M.D. Pavlenishvili, V.V. Koridze.* Microbiologia, **50**, 5, 1981 (Russsian).
9. *G.I. Kvesitadze, N.N. Vorontsova, O.N. Goncharova, V.V. Koridze.* Prikladnaya biokhimiya i mikrobiologiya. **17**, 4, 1981, 569 (Russian).
10. *L.L. Kvechadze.* Doctor theses. Tbilisi. 1991 (Russian).
11. Principles of biotecnology. Tbilisi, 1986 (Georgian).
12. *G.I. Kvesitadze.* Doctor theses. M., 1980 (Russian).
13. *G.I. Kvesitadze.* Dissert. Cand. Biol. Sc. M., 1969 (Russian).
14. *M.D. Pavlenishvili, L.L. Kvachadze.* Sci. of the Georgian SSR. Biological series. 7, 5, 1981 (Russian).
15. *E.D. Mikhin, V.G. Prokofieva, T.I. Mishina.* Prikladnaya biokhimiya i mikrobiologiya, **4**, 5, 1968, 517 (Russian).
16. *E.D. Mikhlin, N.N. Erefeeva.* In: Vitamin B12 i ego primenenie v zhivotnovodstve. M., 1971, 62.

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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BIOCHEMISTRY

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Study of Cell Clones Isolated from Tissue Culture of *Yucca gloriosa L.*

Presented by Academician G.Kvesitadze, December 29, 1997

ABSTRACT. **The suspension culture of *Yucca gloriosa* L. is less aggregated in the active growth stage and the individual cells are growing more actively. The number of cell generations are determined and 8-9 cycles of cell division should occur to produce the viable clone. The biosynthetic potential of furostanols correlates with mitotic activity. As the high yielded biomass provides the high content of furostanolic glycosides the growth processes regulation is the prerequisite of metabolic activity.**

Key words: *in vitro* culture, *Yucca gloriosa* L., mutant strains, heterogeneous suspension, furostanolic steroid glycosides, cloning.

The isolated *in vitro* cultures of plant are available to produce biologically active compounds and increase their number.

The tissue and cell culture of *Yucca gloriosa L.*, one of the main producers of steroid compounds used for making hormonal preparations [1] is selected for investigation. It should be mentioned that these cultures contain less steroid glycosides in comparison with intact plants [2]. Hence, it is preferred to pick out the advantageous cell lines according to the practical selection method. The productivity of these lines is increased via the methods of mutagenesis and somatic cloning [3].

Using the method of comparative analysis we established that the suspension culture of *Yucca gloriosa* L. is less aggregated in the active growth stage.

The study of this culture before plating, the first stage of cloning, was carried out to detect the density, viability and composition (Tables 1a, 1b).

The optimal value for plating on dishes made up 1.1×10^5 cell/ml.

The index of viability is increased in control samples and decreased in mutant strains as a reason of the corresponding response of cells against stress.

Due to the intact cell heterogeneity the control strain divided into fractions has a tendency to intensive growth.

Estimating the percentage ratio between individual cells and agregates, it revealed that the individual cells are growing more actively.

The colonies of various sizes are formed after plating on dishes. Those of 1-3 mm diameter are selected for further studies and after taking them into new medium full growth was observed. The colonies with the diameter of less than 1 mm are characterised by low ability of further development.

The number of cell generations are determined by the formula as follows: $N_t = N_0\times2g$, where *No* and *Nt* are the initial and final numbers of cells in colonies, respectively (4).

According to the formula 8-9 cycles of cell division should occur to produce the viable clone.

Table 1a

Value of viability and cell density of *Yucca gloriosa* control and mutant strains

Variants	Viability %		Quantity of cells	
	before fractionating	after fractionating	before fractionating	after fractionating
K	70+1.3	94+0.9	3.4+0.58	1.1+0.09
Y.g.-0.5	82+1.4	75+1.8	3.7+0.19	1.3+0.02
Y.g.-2	89+1.2	83+1.6	3.5+0.33	1.2+0.01

Table 1b

Content of individaul cell & agregates of *Yucca gloriosa* control and mutant strains

Variants	1 cell		2-5 cell		10 cell		more than 10 cell	
	before fractionating	after fractionating	before fractionating	after fractionating	before fractionating	after fractionating	before fractionating	after fractionating
K	7	21	18	36	22	26	54	17
Y.g.-0.5	28	32	31	37	15	19	26	12
Y.g.-2	16	32	20	32	34	16	30	10

The colonies grown up on dishes are selectively adventageous in comparision with cell lines obtained from callus and suspension cultures. Each of these colonies are produced from individual cells and thus, the high level of genetic and physiologic homogeneity is provided.

During cloning of control and mutant strains of *Yucca gloriosa* L. about 300 colonies are obtained and appr. 60 modified variants isolated as a result of their further subcultivation. Selection is carried out phenotypically, namely, via the growth diversity in the same conditions of cultivation. The part of control and mutant clones have friable, white tissue and high ability of growth and the tissue of badly grown clones is necrotic.

Table 2

Content of steroidal glycosides per passages in *Yucca gloriosa* cell clones obtained from control and mutant strains

Clones	Passages	Content of steroidal glycosides, %		
		I	V	VII
K	2	0.17+0.06	0.18+0.04	0.22+0.03
	4	0.23+0.04	0.27+0.02	0.25+0.05
	16	0.32+0.08	0.25+0.03	0.37+0.04
Y.g. 0.5	2	0.31+0.03	0.30+0.04	0.32+0.02
	9	0.38+0.02	0.37+0.04	0.38+0.03
	14	0.51+0.02	0.54+0.01	0.53+0.02
Y.g. 2	9	0.29+0.05	0.31+0.05	0.30+0.07
	11	0.37+0.04	0.39+0.02	0.39+0.03
	16	0.47+0.05	0.49+0.04	0.49+0.05

The growth index is determined by calculating dry and wet biomass into the several cycles of development (Table 2). The mutant strains are more stable by changes in wet and dry weight as well. These strains are studied in order to investigate the accumulation of furostanolic steroids. It is detected, that the metabolic activity is reduced in badly grown clones and is improved according to growth intensity. Therefore, the biosynthetic potential is high in clones with better growth index. Thus, the biosynthetic activity of furostanols correlates with mitotic activity.

Table 3

Changes of growth indexes by net and dry biomass in *Yucca gloriosa* cell clones obtained from control and mutant strains

Strain	Clone	Net weight	Dry weight
K	2	7.5	1.3
	4	7.9	1.5
	5	8.0	1.7
	13	9.6	2.9
	14	9.0	2.4
	16	10.1	3.2
Y.g.0.5	1	10.6	3.2
	2	10.9	3.3
	4	10.9	3.1
	5	10.8	3.3
	9	9.6	2.9
	10	9.2	2.7
	11	9.4	2.7
	14	9.0	2.4
	17	9.7	2.8
Y.g.2	2	7.9	2.7
	7	7.5	2.4
	9	10.1	3.1
	10	8.0	2.5
	11	7.1	2.3
	15	9.1	2.9
	15	9.1	2.9
	16	13.1	4.1
	17	9.5	3.2

The optimal conditions for the productivity are considered to be the high yielded biomass and high yielded investigated products as well. However, in practical breeding the selection may be carried out by either of these characteristics [5]. Three versions with different growth indices, in particular, with minimum, average and maximum values are chosen from each strain. All of them are studied by their quantitive composition of steroid compounds. The best results have been achieved in clones with high growth index. Accordingly, the selection should be directed towards enhancing the biomass as in general

the total improvement depends on increased biomass. It is established that yielded biomass provides the high content of furostanolic glycosides. In this regard, the growth processes regulation is the prerequisite of metabolic activity. The strengthening of desirable morphological and cytogenetic changes occurs on basis of multiple passages. The citied examples [6,7] show that long-term repeated passages are stabilizing the concrete phenotypical frequency.

The sorting of low and high productive cell lines are based on direct analytical selection. Each of the high productive lines, recloned after several passages, is still divided into low and high subclones. It should be noticed that every successive high productive subclone is more stable [8].

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REFERENCES

1. *E.Kemertelidze, T.Pkheidzé.* Khimiko pharmatsevticheskii zhurnal **VI**, 12, 1972, 44-47 (Russian).
2. *M. Gogoberidze.* Tezisy dokl.nauch. sesii po aktualnym voprosam biokhimii i biotechnologii, Tbilisi, 1985, 65 (Russian).
3. *M.Jaoshvili, S.Karanova, M. Gogoberidze.* Tezisy dokladov 5-oi mezhdunarodnoi konferentsii "Biologia kultiviruemykh kletok i biotecnologii", Novosibirsk, 1988 (Russian).
4. *D.Khalizev.* Genetika, **5**, 3, 1969, 157-160 (Russian).
5. *S.Karanova.* Candidate Theses biol. nauk I-t Biol. Razv. Moskva, 1977 (Russian).
6. *S.Mantell, H.Smith.* Plant Biotechnology. (Ed. Amntell S., Smith H.) Cambridge.
7. *D.Dougal, J.Johnson, G.Whitten.* Planta, **149**, 1980, 292-297.
8. *J. Widholm.* Plant Tissue Culture as a Source of Biochemicals CRC Press, Boca Raton Florida, 1980, 99-114.

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ENTOMOLOGY

C. Chkhubianishvili, M. Burjanadze, N.Goginashvili, N.Kiziria

The Development of *Bacillus thuringiensis* in the Populations of Leaf Miner Insects in Forest

Presented by Corr. Member of the Academy I.Eliava, December 15, 1997

ABSTRACT. **The main pest insects - complex of leaf miner Lepidoptera species are widely distributed in foliage forests of Georgia. The new strain of the entomopathogenic bacteria, *Bacillus thuiringiensis* (Bt) *var.kurstaki* HD-1 (267.000 unit/g) was tested in 1% suspension against III-V instars larvae in the laboratory and natural conditions. The biological effectiveness within the limits 79.0-93.7% Bt doesn't affect on the vitality of entomoiphagous insects.**

Key words: *Lepidoptera, Bacillus thuringiensis*, biological effectiveness.

The forest suffers from injury of several factors. The great economic damage has been brought by pest insects. In forests of Georgia the complex of leaf miner *Lepidoptera* insects are spread: the gypsy moth *Ocneria dispar* L., the brown-tail moth *Euproctis chrysorrhoea* L., the mottled umber moth *Erannis defoliaria* Cl., the winter moth *Operophtera brumata* L. and etc. [1,2]. These pests are characterised by the periodical massive outbreak and the formation of focuses in the large tracts of forests.

The method of microbiological control with pest insects takes the important place in the system of ecological protection of forest as an absolutely safe for forest biocenosis. The bacterial formulations on the basis of infectious origin of the entomopathogenic bacteria *Bacillus thuringiensis* (*Bt*) have been widely used in the microbiological protection of forest from the leaf miner pests [3,4].

Material and methods. The itinerary investigations were carried out at Tbilisi environs (the forest plots of Tskhneti, Kojori). The experiments to the complex of leaf miner pests were conducted in the laboratory and natural conditions. The new bacterial strain of *Bt. var.kurstaki* HD-I (267.000 unit/g) was used. *Bt* formulation was provided by the Hebrew University of Jerusalem (Israel) under the Research Agreement (USAID CA13-017). In tests 1% suspension was used. It determins LD_{50} (median lethal dose) 1,5 g/l to some of *Lepidoptera* insects [5].

The treatment mortality caused by bacteriosis was corrected by Abbot's formula [6]. The biological effectiveness in nature was calculated by Franz's method [7].

Results. The typical broad-leaved forest on territory of Tskhneti consists of the main stocks of trees: oak, hornbeam, ash, elm and etc. The leaf miner pest *Lepidoptera* insects: the brown-tail moth, the mottled umber moth, the winter moth, the gypsy moth are distributed in the planting of this forest. The density of colonization (m/anteroposterior) is following: the brown-tail moth -20-40 larva, the mottled umber moth and the winter moth -25-25 larva, the gypsy moth -5-7 larva. The brown-tail moth was estimated in

oakgrove, the mottled umber moth and the winter moth on hornbeam and ash, the gypsy moth - on the elm trees. The observations and tests were carried out with III-IV instars larvae. The results of laboratory tests for the establishment of *Bt* entomocide activity to pests are presented in Table 1.

Table 1

Effect of Bt formulation on the leaf miner pests

Name of insects	Concentration of formulation, %	Number of larvae	Number of pupae	Number of entomophagous	Mortality, %
The brown-tail moth	1	20	3	1	84.2
K(control)	-	20	11	1	5
The mottled number moth & the winter moth	1	20	-	-	100
K	-	20	4	-	5
The gypsy moth	1	20	2	2	79.0
K	-	20	4	2	5

As the table shows the Bt action is effective to the leaf miner pests and the mortality consists within the limits 79.0-100%. So it was possible to carry out the observations on the natural enemies - entomophagous insects.

It was elucidated that the entomophagous insects (*Braconidae*) both among the contaminated larvae and in control variants have been detected. The parasitism was 5%, the entomophagous insects were remained safe which indicates the Bt action specificity.

Table 2

The results of Bt usage against the leaf miner pests in the plot of Tskneti forestry (The age of larvae IV-V instars, June-July, 1997)

Name of insects	Concentration of formulation, %	Number of insects	Number of pupation	Number of entomophagous	Biological effectiveness, %
The brown-tail moth	1	120	5	2	93.7
K (control)	-	100	28	3	4
The winter moth	1	90	2	-	79.0
K	-	90	2	-	3.3
The mottled umber moth	1	90	1	-	86.0
K	-	90	9	-	3.3
The gypsy moth	1	60	-	3	80.0
K	-	60	27	4	-

The obtained results show high effectiveness of Bt against the leaf miner pests. On the base of preliminary data of the new bacterial formulation [Bt *var.Kurstaki* HD-I (267.000 unit/g)] testing against the main pests of the foliage forest we can make the conclusion that their further wide-scale use is possible. Microbiological control with leaf

miner pests by use of the environmentally safe means will provide the preservation of ecological tolerance in the forest biocenosis.

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REFERENCES

1. *G.Kanchaveli, Sh. Supatashvili.* Forestry Entomology. Tbilisi, 1968, 373 (Georgian).
2. *D.I.Lozovoi.* The pest insects of parks and forest-park plantings of Georgia. Tbilisi, 1965, 268 (Russian).
3. *T.Sh.Imnadze, N.G.Kiziria.* Rec. on the application of bact. prep. for forest prot. from the needle and-leaf gnowed pests. Tbilisi, 5 (Russian).
4. *M.V.Shternshis.* The incr. of effect. of the microbiol. cont. with pest insects. Novosibirsk, 1995, 193 (Russian).
5. *C.Chkhubianishvili.* Photostabiliz. of *Bacillus thuringiensis* formul. for effect. pest cont.. Ann. Rep., Tbilisi, 1996, 11.
6. *W.S.Abbot.* J. Econ. Entomology, **18**, 1925, 256-268.
7. *J.M.Franz.* Anz. für Achadl., **5**, 1968, 65-71.

EXPERIMENTAL MEDICINE

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Changes of Blood Paramagnetic Centres under the Influence of Shock Waves on Kidneys and Membrane-Protector Effect of Agent Plaferon-LB in Experiment

Presented June 13, 1998

ABSTRACT. **The purpose of experimental study was the determination of changes of blood paramagnetic centres and membrane-protector effects of agent Plaferon-LB under the influence of shock waves on kidney during extracorporeal shock wave lithotripsy (ESWL) by electronic paramagnetic resonance (EPR) method. The experiments were carried out on rabbits with lithotriptor "Urat-P" (Russia) under the i.v. anaesthesia. It seems to be advisable administration of Plaferon-LB in clinical practice during ESWL.**

Key words: Extracorporeal Shock Wave Lithotripsy (ESWL), Electronic Paramagnetic Resonance (EPR), Agent Plaferon-LB.

In 1980, in Grosshadern Clinics, Munich, the first ESWL during renal stone diseases was successfully performed by professor C.Chaussy, which markedly changed the tactics of nephrolithiasis treatment, sharply reduced surgical activity and it became possible to recover from stones in approximately 90% of cases without surgical operation [1]. The method sets up on effect of high energy shock waves influence on hard body. Together with study of clinical effectivity of ESWL experimental and clinical investigations for determination of shock waves influences on the renal parenchima, other organs and systems were carried out. It has been established, that shock waves cause transient reversible changes of renal parenchyma [2,3]. The pathological changes, that take place in other organs, reflect in blood.

The object of experimental study was the determination of changes of blood paramagnetic centres and membrane-protector effects of agent Plaferon-LB under the influence of shock waves on kidney during ESWL by EPR method. EPR is called to the phenomenon of resonant engulfment of electromagnetic field energy of superhigh frequency by particles possessing noncompensative electronic moment. Changes of paramagnetic centres of blood revealed by EPR method indicates the state of metabolism and function of blood cells, that gives opportunity to determine biophysical and biochemical changes running on the molecular level.

Experiments were carried out on "Shinshila" rabbits of 1.5-2 kg weight. Animals under i.v. anaesthesia (thyopental natrium 25 mg/kg) were placed in lithotriptor "Urat-P" (Russia) based on electrohydraulic effect with X-ray location. Under contrast substance (Verographin 60%-2ml/kg) visualization of kidneys and focusing of shock waves on renal

pelvis were undergone, followed by influence of waves on kidney. Thus, we have created the experimental model of ESWL. The capacity of waves in the foci was fluctuated up to 13-16 kV, and its total amount on both kidneys was 3000. For registration of blood EPR spectra peripherial blood was taken just after lithotripsy, after 24 hours, 3 and 7 days from lithotripsy. The blood specimen 1-1.5 ml was placed in polyethylenic tubes and kept in liquid nitrogen (- 196^0 C). EPR spectra were registered by radiospectrometer - RE-1307 (Russia), by using of quartz duar, placed in resonator of spectrometer. The animals were divided into three groups. The first group was composed of intact animals. The second group was control, where the animals underwent the above-mentioned intervention. The third experimental group of animals together with before-mentioned interference were injected intravenously by the agent Plaferon-LB 0.5 ml/kg during three days up to lithotripsy and three days after it. In each serial the number of animals was five.

From the analysis of obtained experimental data it is evident, that changes of blood paramagnetic centres intensity starts 24 hr after stopping shock waves influence (Table 1).

Table 1

Changes of blood paramagnetic centres intensity I (mm/mg) after shock waves influence on kidney in the animals of control group.

Terms of experiment	Adrenorec. inact.form g = 20.1	Mn^{2+} cont.compl. g = 2.14	FeS-N0 g = 2.03	Mo^{4+}cont. compl. g = 1.97	Ceruloplasmin g = 2.056	Fe^{3+} transferin g = 4.3	MetHB g = 6.0
norm	-	3.0 ± 0.4	1.0 ± 0.2	-	10.0 ± 0.9	30.0 ± 1.2	-
just after finishing	-	3.0 ± 0.5	2.0 ± 0.95	-	12.0 ± 0.8	27.0 ± 1.0	-
24 hours	10.0 ± 0.8	6.0 ± 0.5*	2.5 ± 0.5*	2.0 ± 0.3	18.0 ± 0.5*	28.0 ± 1.3	17.5 ± 1.0
3 days	5.2 ± 0.5	6.0 ± 0.8*	3.0 ± 0.3*	2.0 ± 0.3	20.0 ± 1.3*	20.0 ± 1.5*	15.0 ± 1.3
7 days	2.0 ± 0.5	5.0 ± 0.5	3.0 ± 0.5*	1.0 ± 0.3	17.0 ± 0.9*	30.0 ± 1.2	6.6 ± 0.5

The changes signed by * are significant to norm ($P<0.005$)

At this time EPR signal intensity of oxidized ceruloplasmin increased by 1.8-times in comparison with norm, elevation was ongoing and up to third day achieved the pick. Elevation of concentration of oxidized ceruloplasmin indicated the activation of lipid peroxidation in the body of animals and the reduction of blood antioxidant capacity. EPR signal reduction of Fe^{3+} - transferin revealed on the third day could be caused by increasing of concentration of oxidized ceruloplasmin and decreasing of its peroxidase activity. In relation of this the connection of iron ions with apotransferin was hampered, which in its turn contributed to reduction of antioxidant capacity of blood activation of lipid peroxidation in body.

Intensive EPR signals of Mn^{2+} - containing complexes (g = 2.14), nitric oxide complexes with nonhemic iron (g = 2.03, FeS-NO), xantinoxidase (g = 1.97) and methemoglobin (g = 2.03) in the blood EPR spectrum were revealed after 24 hours from lithotripsy. As it is known, nitric oxide and xantioxidase are the powerful generators of free oxygen forms - superoxide and hydroxilradicals. Appearance of methemoglobin EPR signal in blood EPR spectrum suggests red cells hemolysis. The formation of methemoglobin is possible through oxidation of Fe^{2+} - hemoglobin by hydroxylradicals (OH). Increase of EPR signals intensity of Mn^{2+} - containing complexes [4] in the blood EPR spectrum after 24 hours and 3 days from stopping of shock waves influences suggested also the activation of lipid peroxidation and damage of membraneous structures.

During the 24 hours and 3 days period after experiment in the blood EPR spectrum EPR signal characterizing for inactivated form of adrenoreceptors was registered. As it is well known, that adenylatcyclase system, which in its term is very sensitive to Mn^{2+}- ions plays an important role in the activation process of adrenoreceptors [4]. Furthemore in many studies it is shown [5-8], that in the process of activation of lipid peroxidation, inactivation of superoxidismutase and generation of free oxygen forms, inactivation of adrenoreceptors take place. So, the cause of adrenoceptor inactivation could be the activation of peroxidation, damage of membranes, structural changes of receptors and separation of adrenoreceptors from adenylatcyclase system via Mn^{2+}- ions exitance. Inactivation of adrenoreceptors in its turn causes supperssion of compensative-repairing reactions of body. On the 7th day of experiment the changes of paramagnetic centres tendency to normalization were revealed, which suggested the stabilisation of pathologic process and its reversibility.

Thus, in the samples of blood of control group animals taken in early periods after the influence of shock waves on kidneys decrease of blood antioxidant capacity, damage of membraneous structures, formation of generators of free oxygen-nitric oxide and xantinoxidase, inactivation of adrenoreceptors and suppression of defensive capacity of body took place.

Changes of intensity of blood paramagnetic centres in the experimental group of animals with the agent Plaferon-LB as well as in control group start from 24 hours after lithotripsy (Table 2). At this period EPR signal intensity of oxidized ceruloplasmin was 1.6-times more in comparison with norm, but the elevation degree is less by 20% than in control group at the same period . Elevation was ongoing till the third day and for the 7th day achieved initial indices.

On the background of Plaferon-LB treatment, the intensity of Fe^{3+}- transferin EPR signal in the blood EPR spectrum was decreased insignificantly in comparison with control group, which suggested the maintenance of peroxidase activity of ceruloplasmin and antioxidant capacity of apotransferin. Therefore, during the administration of Plaferon-LB the antioxidant capacity of blood was partially maintained.

Table 2

Changes of blood paramagnetic centres intensity I(mm/mg) after shock waves influence on kidneys in the animals of experimental group

Terms of experiment	Adrenorec. inact. form g = 2.01	Mn^{2+}-cont.compl. g = 2.14	FeS-NO g = 2.03	Mo^{5+}cont. compl. g = 1.97	Ceruloplasmin g = 2.056	Fe^{3+}-transferin g = 4.3	MetHB g = 6.0
norm	-	3.0 ± 0.4	1.0 ± 0.2	-	10.0 ± 0.9	30.2 ± 1.2	-
just after finishing	-	3.0 ± 0.4	2.0 ± 0.3	-	11.2 ± 0.8	33.1 ± 1.2	-
24 hours	+6.0 ± 0.5	4.1 ± 0.6	3.0 ± 0.5	-	+16.0 ± 0.5	27.1 ± 1.5	+10.0 ± 1.1
3 days	+3.1 ± 0.6	+3.0 ± 0.4	3.0 ± 0.5	2.1 ± 0.2	+18.2 ± 1.1*	+28.1 ± 1.2	+12.1 ± 1.2
7 days	-	+2.5 ± 0.2	+1.1 ± 0.1	-	+12.2 ± 0.7	30.1 ± 0.8	-

The changes signed by * are significant to norm (P<0,005).

The changes signed by + are significant to control (P<0,005).

EPR signals of Mo^{5+}- containing complexes, nitric oxide complexes with nonhemic iron, xanthinoxidase and methemoglobin in the blood EPR spectrum were revealed after

24 hours and on the 3rd day under the action of Plaferon-LB.

It should be emphasized, that the elevation of signal intensity was more in comparison with the blood of control group of animals (Table 1). This fact suggested the reduction of free oxygen radicals generators on the phone of Plaferon-LB - formation of nitric oxide and xantinoxidase, that contributed to decrease of lipid peroxidation, maintenance of membrane, especially red cell membrane integrity, decrease of methemoglobin level and recovery of blood antioxidant capacity. During reduction of lipid peroxidation intensity the hallmark EPR signal of adrenoreceptor inactivation was revealed after 24 hours from lithotripsy and had less intensity in comparison with control, suggesting about the maintenance of compensative-defensive capacity of body under the action of Plaferon-LB.

On the 7th day of observation all studied parameters of blood paramagnetic centers of experimental group animals were equalized to initial indices.

Thus to summarize, the agent Plaferon-LB has capacity of correcting exogenous action and causes regeneration of antioxidant potential of body, maintenance of active state of adrenoreceptors during shock waves influence. For above-mentioned features of specimen it seems to be advisable administration of Plaferon-LB in clinical practice during ESWL.

Tbilisi Institute of Urology

REFERENCES

1. *JY. Gillenwater*. In: Adult and pediatric urology (eds. JY.Gillenwater), 1996, p.913-920.
2. *A. Neimark, A. Fidirkin*. 4, 1997, 11-14 (Russian).
3. *F. Brummer, Th. Brauner, DF. Husler*. World J. Urol., 8, 1990, 224-232.
4. *F. Grengard, NY. Robinson*. Advances in cyclic nucleotide research. 14, 1981, 132.
5. *B. Kilasonia, T. Sanikidze*. Sakart. Samed. Moambe, 1995 (Georgian).
6. *T. Sanikidze*. - Spermatogenezis dargvevis zogierti mekhanizmi dazianebul satesle jirkvalshi. Sadisertacio Macne, biol. mecn. dokt.., 1997 (Georgian).
7. *M. Pulatova, G. Rikhireva*. - Elektronnii paramagnitnii rezonans v molekulyarnoi radiobiologii. M.,1989, 228 (Russian).
8. *V. Kipiani, T. Sanikidze, N. Chelidze*. First Europ. Cong. of Pharmacology, Milano, 1995, June, 247.

EXPERIMENTAL MEDICINE

L. Jorjoliani, T. Churadze, T. Giorgobiani

Air Pollution and Allergic Diseases in Children of Tbilisi

Presented by Academician T. Oniani, September 28, 1998

ABSTRACT. **The concentration of main air pollutans in Tbilisi exceeds the maximum allowable concentration (MAC) from 1.1 to 5.4 times. The frequency of children allergic diseases varied among zones and increased significantly with the air pollution intensity ($p<0.001$). 16073 children aged 0-15 years have been studied using the screening method.**

Key word: ecology, air pollution, children, allergic diseases.

During the last decades special attention of scientists has been focused on enviromental pollution intensity and increasing effect of a large number of outdoor allergens (SO_2, NO_2, phenol, combustion gases, etc.) on formation of allergic diseases [1,2]. Children's population is the most sensitive to the influence of unfavourable enviromental factors. This is associated with a number of physiological peculiarities of a child's organism [3,4].

The economic and geographical location of Tbilisi leads to the widening of external and internal urban communications and decreases traffic capacity. High transport intensity and low traffic capacity increase the amount of combustion gases and exert a negative influence on the ecological situation in the city. Intensive urbanization processes all over the world still continue to affect the prevalence of allergic diseases even if all the city indrustrial enterprises are closed down. Motor transport and fuel combustion are inevitably associated with the exhaust of carbonic acid gas, carbon monoxide, nitrogen oxides, polycyclic hydrocarbons and allergy inducers. It has been established that xenobiotics absorption on pollen and other allergens increase their immunogenicity hundred times. The most active are formaldehyde, thyocianates, nitrogen and sulphur oxides and toxic radicals [5,6,7].

In the present work the dependence of the frequency of allergic diseases in children on the air pollution intensity has been studied. The data on the laboratory control of air samples from seven air pollution observation zones in seven districts of Tbilisi have been collected in Tbilisi National Enviromental Monitoring Center.

The prevalence and structure of allergic diseases (bronchial asthma, polynosis, atopic dermatitis, urticaria and Quincke' s edema) have been investigated by examining an occasional representative group of children (16073 children aged 0-15 years) according to specially developed unified methods including a screening-questionnaire, a detailed map of epidemiobiological analysis and unitary diagnostic criteria of allergic diseases in children.

In Tbilisi the prevalence of allergic diseases in children was 18.8%. Atopic dermatitis has the highest rate – 7.7%, urticaria and Quincke' s edema are recorded in 4.4% of cases,

polynosis amounts to 3.8%, bronchial asthma is found in 3.1% of cases.

The analysis of the air pollution intensity in the studied districts has shown different quantitative and qualitative air composition. The comparison of the air pollution data with maximum allowable concentrations (MAC) of separate chemical components revealed different contamination levels in the investigated zones. In the first zone MAC was exceeded in 4 components (dust by a factor of 3.8; carbon monoxide by a factor of 1.5, phenol by a factor of 4.2). In the second zone MAC was exceeded in 3 substances (dust by a factor of 4.3, phenol by a factor of 1.6, formaldehyde by a factor of 5.4). In the third zone the excess of MAC was observed in 2 components (dust by a factor of 2.7, carbon monoxide by a factor of 1.4). In the fourth zone MAC was exceeded in 4 components (dust by a factor of 1.6, carbon monoxide by a factor of 1.2, phenol, by a factor of 2, formaldehyde by a factor of 5.4). In the fifth zone in 2 components (dust by a factor of 2.4, formaldehyde by a factor of 4.2). In the sixth zone in 3 components (dust by a factor of 2.4, carbon monoxide by a factor of 1.4, phenol by a factor of 1.7) and in the seventh zone no markable excess of MAC in two substances was found (dust by a factor of 1.4, phenol by a factor of 1.2). Thus, in all the investigated zones the excess of substances of the second and third class of danger was revealed.

Taking into account the different composition of air pollutants in the districts under investigation the total air pollution index (T) was used for a comparative hygienic assessment of the pollution intensity (Table). This allowed one to classify the investigated districts into conventionally pure (Nadzaladevi), with relatively low air pollution intensity (Samgori and Isani) and polluted (Chugureti, Gldani, Saburtalo and Didube) districts.

Table

Relationship between the prevalence rate of allergic diseases in children and the air pollution intensity

District (zone)	Number of examined children		Rate of allergic diseases		Total index of air pollution (T)
	abs.	%	abs.	%	
1. Zone – Gldani	1261	7.8	485	38.4	14.55
2. Zone – Didube	2903	18.1	503	17.3	10.59
3. Zone – Samgori	1091	6.8	241	22	6.63
4. Zone – Chugureti	2742	17.1	963	35	16.13
5. Zone – Saburtalo	1902	11.8	557	29.2	10.78
6. Zone – Isani	1465	9.1	267	18.2	7.72
7. Zone – Nadzaladevi	4709	29.2	60	1.3	3.94

The analysis of the data obtained has shown the dependence between the increasing rate of allergic diseases in children and chemical air pollution intensity ($p<0.001$). So, in the pure district it was 1.3%. In the contaminated zones the allergic disease prevalence was high (7.3%-38.4%).

In the districts with high air pollution intensity the allergic diseases in early ages, heavier development and the increase of the polyvalent sensibilization frequency ($p<0.05$) have been recorded.

Thus, the obtained results indicate a significant influence of the air composition on the prevalence of allergic diseases and its growth with the pollution intensity in the district.

I. Paghava Scientific Research Institute of Pediatrics

REFERENCES

1. *D. G. Soldatov, S.N. Andreev, I.A. Kusakina.* Pulmonologia, 4, 1996, 84-88, (Russian)
2. *B.A. Shamov, T.G. Malanicheva, R.Z. Zakiev.* Vestnik dermatologii i venerologii. 1, 1997, 10-12. (Russian).
3. *V.F. Demin, S.O. Kluchnikov.* Pediatria, 1, 1995, 98-101 (Russian).
4. *A.G. Shamova, T.G. Malanicheva.* Kazan Med. journ. 3, 1995, 237-240 (Russian)
5. *U. E. Veltishev, O.B. Sviatkina.* Rosiiski vestnik perinatologii i pediatrii. 1, 1995, 4-10.
6. *S.H. Arshad, S. Matthews, C. Gant et al.* Lancet 331, 1992, 1493-1497.
7. *S. Croner.* J. Pediatr. 121, 1992, 58-63.

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EXPERIMENTAL MEDICINE

M.Artilakva, N.Mchedlishvili, I.Pavlenishvili

Neurotransmitters Level in Blood, Immunologic Changes while Newborns Adaptation Period and Perinatal Hypoxic-Traumatic Damages of CNS

Presented by Corr. Member of the Academy T.Dekanosidze, May 18, 1998

ABSTRACT. **We studied the role of monoamines and immunologic factors in adaptation process on peripheric blood at both practically healthy newborns and of those having perinatal pathology of CNS. Close correlations between the level of monoamines produced by hypothalamus and immune markers were revealed, which points to the common tropic character of metabolic processes and coordination from the side of CNS.**

Key words: monoamine, histamine, serotonin, immunologic markers.

The adaptation of a newborn to the environment reflecting the general regularities of H.Selie's adaptation syndrome is of a phase character from the very first days of life. This process is a function of CNS and the trophotropic part of vegetative, above-segment and limbico-reticular complex. It provides keeping of individuals' homeostasis and formation of important immune reactions, regulates the rhythm of respiratory, cardiovasomotor and digestion organs functioning, the processes of energy exchange with environment and maintaining of constant temperature.

It is established that anatomic integrity and functional maturity of the hypothalamus structures as of the highest coordinative centre of vegetative nervous activity and regulative organ of tropic processes is responsible for the level of mediatory substances secretion and constancy of their ratio to other humoral indices. By the active involvement of monoamines in synaptic complexes the balancing of sympathetic-parasympathetic activity, equilibrium of neuro-endocrine systems and corresponding readiness to adaptation processes can be achieved. Absolute and relative level of neurotransmitters in the organism is the basis of vital activity of reflex reactions and proceeding of physiological processes, whereas in the case of disorder (or disbalance) the pathogenic ring of symptomocomplex of deseases develops. The synaptic-mediative function of monoamines as regulators of tropic reactions of hypothalamic level, elucidates the importance of their levels constancy for functioning of central-reflex ring of organism's immune reaction.

To maintain organism's inner environment immunologic supervision is of great importance. The role of immune mechanism in homeostasis keeping is expressed not only by the resistance to the infection but also by the normal functioning of a number of systems and generally by the anatomic-functional maturation and developmental processes corresponding to the embryonal and postnatal adaptation periods. Decline of protective-compensative activities of the organism, immaturity or disturbance of immune

reactions can cause the pathologic autoimmune reaction directed against the self-organism. On the one hand, the above-mentioned is due to the breaking of CNS regulatory function, whereas on the other hand, it becomes the reason of severe disorder of CNS [1].

According to the principles of modern neurology perinatal hypoxic-traumatic damages of nervous system are treated as breaking of blood circulation in cerebral tissue of a diffuse and local character with haemorrhagic and ishemic insulte zones, disorders of nervous tissue metabolism and very often in the form of neurons irreversible dystrophy. Such interpretation of pathogenesis of desease increases interest to biological monoamines as vasoactive, membrano-active substances, which according to the experimental data participate in reflex regulation of vascular wall tonus, change its permeability, selectively affect the circulation and generally blood circulation of the organism.

Immunologic factors have the leading role in the formation of disadaptive syndrome while perinatal hypoxic-traumatic damage, in revealing of a number of pathologic reactions as a syndrome of pathogenic chain and in development of organic functional deficiency. In literature of 80ies there are works in which monoamines (histamine or serotonin) are determined in case of perinatal pathology without setting of necessary humoral background of their synaptic activity and complete clinico-neurologic study [2-4].

In our experiments quantitative and functional parameters of biological monoamines – histamine, serotonin and some immunologic markers particularly T- and B-lymphocytes were determined in blood of both practically healthy newborns and those of having hypoxic-traumatic damage of CNS.

Histamine and serotonin levels were determined according to T.Mescheriakov's complex method (1984) using the spectrophluorimeter of Hitachi firm. Immune indices, particularly the amount of T- and B-lymphocytes, were defined by spontaneous and complementary roset-forming method [5]. Functional activity of T-lymphocytes was defined by means of blasttransformation reaction after Goldman and Levin (1964), modified by Borisov and Rachkov (1972), activity of T-suppressors according to the T.Sakane and L.Green method (1977), concentration of immunoglobulines – by the method of radial immunodiffusion [6].

30 practically healthy and 85 patients of age from 5 to 40 days were clinically and laboratorily examined. Diagnosis of perinatal hypoxic-traumatic ethiologic disorders of CNS, determination of clinical forms and heaviness of the desease were performed according to I.Yakunin and E.Yampolskaya classification (1979) [7].

As criteria proving the existence of pathology the following markers were used: local and general disorders of motoric-reflex sphere, visceral-vegetative disorders with suppresion of vital functions, general cerebral and local neurologic symptoms, presence of pathologic reactions (convulsive activity) and of pathologic reflexes, liquordynamic disorders and meningial symptomatic, metabolic changes both in blood and liquor. In each case anamnesic data concerning pregnancy period and delivery were specified. The diagnosis was verified using nerosonoscopy, EEG, encephaloscopy, X-ray diagnosis and in cases of lethal outcome – by the pathomorphologic conclusion.

It was revealed that in the case of timely newborn having perfect anatomo-physiological parameters, general maturity corresponds to the certain level of amines and other humoral factors [among them factors of humoral homeostasis] secretion and metabolism.

The obtained data confirm considerations of other investigators according to which the level of metabolism affects the process of neurotransmitters synthesis and the lasts by means of via regulation of hypothalamic structures mediation and reflextropic and immune reactions balancing, seem to be regulators of vital processes [2-5].

Indices of mediators are in reliable correlation with the data of acid alkaline equilibrium (R-M 0.768), electrolytes (R-M K^+ 0.628; R-M Na^+ 0.736; R-M Ca^{++} 0.766), and sugar level (R-M 0.854) in blood. Similar close correlative relations are found in blood between the level of monoamines produced by the hypothalamus and immune indices (of negative direction with indices of B-lymphocytes activity and of positive direction with analogous one's of T-lymphocytes). These indices are stable already from the 5th day after birth, approximate to the norm of adults and are suitable for identification of pathology.

Following the worsening of patient's clinical condition high level of histamine (0.44±0.05 mM e^{-1}), serotonin (0.18±0.01 mM l^{-1}) and their ratio (K=2.43±0.12) is observed (Fig.). This process reliably correlates with electrolytes content (R-M 0.67-0.750), acid alkaline balance (R-M 0.671-0.750) and sugar content (R-M 0.850).

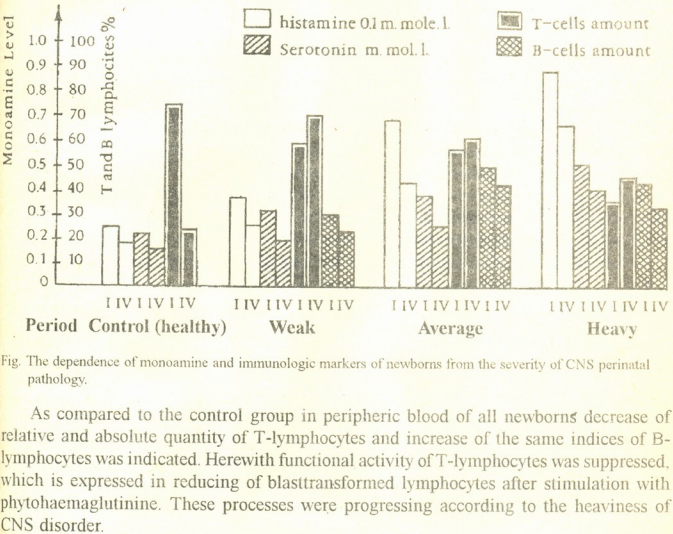

Fig. The dependence of monoamine and immunologic markers of newborns from the severity of CNS perinatal pathology.

As compared to the control group in peripheric blood of all newborns decrease of relative and absolute quantity of T-lymphocytes and increase of the same indices of B-lymphocytes was indicated. Herewith functional activity of T-lymphocytes was suppressed, which is expressed in reducing of blasttransformed lymphocytes after stimulation with phytohaemaglutinine. These processes were progressing according to the heaviness of CNS disorder.

In mediate and heavy forms of CNS hypoxic damage in all newborns was mentioned reduction of T-cells suppressive activity on the background of B-lymphocytes increase, which might condition the development of cytologic and humoral autoimmune reactions. The last one intensifies pathologic processes and results in autoimmune and autoallergic

complications.

The mentioned process is proved by the high level of monoamines typical to stressory state with close correlation of immune indices and their progress in the course of desease hardening.

Close correlation of synaptic mediators level with indices of immune system while both physiologic and pathologic course of newborn's adaptation period points to the common tropic character of metabolic processes and governed coordination from the side of CNS.

On the hypothalamic level of the disorder close correlative relations of redox processes suppression, electrolytic disbalance and general metabolic disturbances (characteristic to CNS perinatal hypoxic-traumatic damage) with disorders of neurotransmitters secretion and immune homeostasis are rather stable and extensive.

Aforesaid is the main pathogenic factor in the formation and development of aggraviating syndromatic complex in the course of pathology (and clinical picture of disease) Described pathogenetic mechanisms while deepening of existed hypoxia and corresponding clinical hardness of disease finally result in severe organic defect of nervous system.

By the end of the first month in 78% of patients stable clinical improvement was indicated. At the end of newborn's period despite the mentioned improvement the full correction of metabolic disorders (take into account monoamines level in blood and deviations of immune sphere) couldn't achieve with reliably difference from the healthy groups ($P \leq 0.005$-0.05) which should be taken into consideration while planning of cure scheme and determination of out patient and clinical supervision duration. Investigation of discussed parameters should be continued in age dynamics.

Considering regulation of hypothalamic mediation as a principle mean of pathogenesis treatment, to achieve the balanced level of neurotransmitters, inclusion of antihistamine and serotoninergic preparations in generally accepted medicinal scheme is necessary. For the regulation of immune status disturbances immunomodulators should be used.

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REFERENCES

1.*G.Nizharadze, I.Pavlenishvili.* Akhalshobilta daavadebebi. Tbilisi, 1990 (Georgian).
2.*G.V.Abramchik et al.* J.Fiziologia Cheloveka, 16, 2, 1984, 235-253 (Russian).
3.*N.N.Go' ivastikov.* J.Imunologia, 3, 1981, 22-24 (Russian).
4.*G.V.Idova, M.A.Cheido.* Akademia med. Nauk SSSR, 5, 1981, 39-41
5.*M.Jondal et al.* J.Exp.Med., **136**, 1972, 207-222.
6.*G.Mancini et al.* Immunochemistry, 1965, 2.
7.*Yu A.Yakunin et al.* Bolezni nervnoi sistemy u novorozhdennykh i detei rannego vozrasta. M., 1979, 277 (Russian).

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M. Epremashvili

Diabetes Mellitus and its Peculiarities in Georgian Jews from Tbilisi

Presented by Corr. Member of the Academy T.Dekanosidze, February 11, 1998.

ABSTRACT. **Diabetic rethinopathy with frequent cases of optic nerve atrophia is the main complication of the patients with diabetes mellitus in the Georgian Jews. Cardiovascular diseases are mainly among the disorders concomitant to diabetes mellitus. Big fetus in woman in childbirth with diabetes mellitus is a risk-group from the point of view of diabetes development, especially when diabetes mellitus is accompanied by general stoutness in pregnants. The complications of the same nature are registered in the sick members of the family. This is determined by heredity and decompensated form of diabetes simultaneously.**

Key words: diabetes mellitus, Georgian Jews.

Historical records testify that Jews live in Georgia for twenty - six centuries and they are called Georgian Jews. Marriages among Georgian Jews happen with account of religious factors and take place only within the members of this community.

It is established that in patients with diabetes mellitus, certain disorders such as cardiovascular diseases (twice), blindness (10 times), gangrene and extremity amputation (20 times) are more frequent than in ordinary inhabitants.

Spreading of risk-factors differ in various populations and economic and geographic regions. It depends on such characteristics of population as age structure, mode of life, nutrition type, structure of diseases, geographical conditions and same social factors.

The article aims to study diabetes mellitus complications and concomitant diseases in the Georgian Jews living in Tbilisi .

By means of special questionnaire compiled by World Health Organization 700 families lived in Tbilisi were questioned. 100 families (209 patients), appeared to have diabetes mellitus.

Along with diabetes mellitus, various diseases were revealed in the investigated population. Such cases make 30.04% of patients (67 patients). It should be noted that the above-mentioned phenomenon was often of familia character, i.e. one and the same disease was registered along with diabetus mellitus in the same families.

Two groups are singled out from revealed patients. The first group represents diabetes complication and the second group which is concomitant to diabetes mellitus.

Diabetic retinopathy that causes the atrophy of optic nerve is the first by frequency among the patients of the first group. The pathology is registered in 23 cases, that makes 11% of investigated patients. Diabetic microangiopathy is the second by frequency and is registered in 20 cases, that makes 9.57%. Diabetic nephropathy takes the third place. It

is revealed in 14 cases, that makes 6.69%.

More seldom is the case of hypo and hyper-glycemic comatose state connected with the regime of diabetic treatment (10 cases are registered, that makes 4.7%).

Thus, pathologies that are directly connected with diabetes mellitus are revealed in 67 patients, that makes 30.04% (Table 1).

Table 1

Complications of patients with diabetes mellitus

The name of the disease	man	woman	total	%
Atrophy of optic nerve	9	14	23	11
Diabetic microangiopathy	8	12	20	9.57
Diabetic nephropathy	4	10	14	6.69
Hypo- and hyperglycemic coma	4	6	10	4.78

The second group of pathology is concomitant to diabetes mellitus and is represented by cardiovascular diseases (Table 2).

Table 2

Diseases concomitant to diabetes mellitus

The name of disease	man	woman	total	%
Atherosclerosis	5	8	13	6.39
Hypertension	18	20	38	18.13
Myocardial ischemia	7	13	20	9.5
Cerebral circulation disorder	5	6	11	5.27
Miscellaneous items	4	7	11	5.27

Among the diseases atherosclerosis was revealed in 13 cases, that makes 6.39%, atherosclerosis with hypertension was found in 38 cases (18.13%), myocardial ischemia is registered in 20 cases (9.5%), cerebral circulation disorder - in 11 cases (5.27%). Various diseases, such as cholelythic disease, psoriasis, sepsis are registered in 11 cases (5.27%).

The relationship of diabetes mellitus and general stoutness must be considered separately. During the questionary it appeared that some patients had begun to grow stout even before the diabetes manifestation and at the moment of manifestation it makes 32%. After the manifestation some patients had lost weight and at the moment of investigation stoutness was registered in 11.49%. At the same time stoutness of II and III degree was revealed in men and women and mostly in the last ones.

It must be mentioned that the disorders often had familial properties of heredity, i.e. the same disorder was registered in the same family.

The problem of generally stout mass of women with diabetes mellitus and the mass of their fetuses is of special interest. Among the women with the stoutness of II and III degree 12 women had one big fetus, nine women – 2 big fetuses, 2 women – 3 fetuses. In total 15 stout women delivered 23 big fetuses (Table 3).

Table 3

The weight of fetuses in the women with diabetes mellitus and general stoutness at the moment of delivery

Women age	fetus mass (more than 4.5 kg)
16-19	-
20-24	5
25-29	16
30 and more	2

Table 4

The weight of fetuses in the women with diabetes mellitus

Women age	fetus mass (more than 4.5 kg)
16-19	5
20-24	7
25-29	8
30 and more	3

In addition 44 women without any indicator of stoutness delivered big fetuses in 23 cases (Table 4).

Institute of Therapy

საქართველოს მეცნიერებათა აკადემიის მოამბე, 158, №2, 1998
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LINGUISTICS

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Rhetoric and Advertising

Presented by Academician A. Gvakharia, September 25, 1997

ABSTRACT. **Advertising uses rhetoric figures to achieve its aim, which helps it to persuade a listener in correctness of an advertisement, and to persuade him/her to make a decision appropriate for a creator of an advertisement.**

Key-words. advertisement, rhetoric, persuasion, orator.

The aim of advertising is not to hide from anyone. It consists in attracting as many consumers as possible and in selling as many goods as possible. The process underway in any audience, with all the difficulties that should bare an advertisement from the day of its appearance until time when a consumer makes his/her decision, is quite complicated, deep, psychological and individual. Thus, those who create advertisements have to take into account the uncountable quantity of factors to achieve the final aim. In this complicate process, that is expressed in AIDA (AIDA - attirer l'Attention - draw the attention; susciter l'Intérêt - to arouse interest; provoquer le Désir - to provoke desire; faire Acheter - to make someone buy) formula, we will draw your attention to only one point of this formula: this is the fascination of the audience, that should be followed by its confidence. For illustrating this factor we will bring up one of the "Kenzo"s advertisements:

« Kenzo has remembered that in the nature certain creatures know how to use their charms to capture their victims. »

The advertisement knows well how to charm us. For this its creators have to play on psychology, needs, feelings, instincts and emotions of the audience. As soon as the proper feelings are born in the « victim », the advertisement tries to direct the commenced process so that the object is forced to satisfy the desire provoked by the charm.

What are the tools that the advertisement uses to play on the emotions, how does it create them, or how does it persuade the audience? Perhaps, this is the Rhetoric that plays a significant role in the process of persuasion? And the Rhetoric is one of the important bases that supports the modern advertisement as it represents the startling point for all emotions and feelings. Rhetoric is an art of persuasion, art of speaking and eloquence; it is the theory of the oratory [1]. Some French researchers call the creators of advertisement a « polyvalent » orator as they use the technique of the rhetoric in every means of mass media. They often need to recreate what was already discoverd and established in the classical rhetoric. Aristotle in his « Rhetoric » determined for the centuries to come rules of the persuasion theory, and it remains the best text-book for the creators of advertisement. In his turn, French semiostylist Géorges Molinié explains the persuasion theory in the following way: «It is a technique, a talent and an artistic virtuosity at the same time. A means of persuading is essentially a language with the totality of its composing parts, and, in the exterior form, the most fugitive, the most unstable, but also the most lively and

the most powerful: the individual speech. This speech should be considered like an orchestral harmony: phrases that we pronounce with words and expressions that we have chosen, look and gestures that we put into it, information which we give away and also which we demand, and which we contest, argument that we make, aims and modalities that we animate. Thus, this is a unity of the logico-discussive, or the strategico-linguistic, that mingles the verbal, the physical and the logical, the moral and the social» [2].

According to Aristotle, three types of arguments are used in the process of persuasion: ethos and pathos, that have the affective role, and logos, that is rational in its character [3]. He thinks that pathos is the unity of emotions, feelings and sentiments, that an orator should provoke in a listener. The author underlines that the persuasion can be achieved after certain feelings are born in a listener. G. Molinié believes that « the feelings play the role of a lever, that gives the possibility for sentimentalism ». Quintillianous agrees with Aristotle, and says that the means that influence the listener can be divided into rational and affective groups. To the former group belong the arguments, to the latter - 1) ethos (which means the mood of an orator, his frankness, means, that he use to attract attention) and 2) pathos (meaning the way how an orator should influence desires, feelings and emotions of an audience to better persuade them).

Cicero, in his turn, outlines three main types in the art of rhetoric: **docere** (explanation, definition), which is the argumentative part of the expression; **delectare** (liking) - the funny, amusing part of the expression; **movere** (fascination) - the means and tools that influence and fascinate a listener. The classical theory of the oratory is divided into 5 parts [4]. The modern advertising business uses the same model, on which any advertisement can be based. 1. **Inventio**: the argument seek. In the advertisement, it is the equivalent of the survey of market, motivation, and search for the creative methods. 2. **Dispositio**: the exposition of ideas, arguments, facts of the expression. Its analogy in the advertising is the advertising strategy, different methods of developing an advertisement, so-called, «lure»: a title, sub-head, text of an advertisement, the main phrase, motto. 3. **Elocutio**: the choice of rhetorical figures, of word combinations, verbal expression. The search for the most effective form of the expression. In advertising - advertisement creation, conception and editing of an advertisement. 4. **Memoria**: all methods, means, techniques, that give an orator an opportunity to remember everything that he/she has to pronounce. 5. **Pronunciatio**: the art of expressing. In press advertising this part has the same freight as in audio advertising for if the object reads text of an advertisement silently, the graphic is always followed by the voicing. He/she pronounces the text in his/her mind.

We can conclude that modern advertising reconstructed the majority of the classical rhetorical figures, but it has not discovered a new form for the art of persuasion.

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REFERENCES

1. *B. Lamy.* La Rhétorique ou l'art de parler. Pralard. éd. de 1688.
2. *G. Molinié.* Dictionnaire de Rhétorique. Livre de Poche. 1992.
3. *Aristote.* Le poétique et la rhétorique. Presse Universitaire de Lyon. 1981.
4. *O. Reboul.* Introduction à la rhétorique. PUF. 1991.

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PHILOLOGY

A. Ayfer Altay

Forces That Manipulate "Translation"

Presented by Academician A. Gvakharia, February 6, 1998

ABSTRACT. **The paper deals with forces that manipulate translation. The author discusses the process of translation in historical perspective, covering the Middle Ages to the present day. Recent trends in the fields are analyzed.**

Key words: translation, patron, policy, poetics, deconstruction, "refracted text".

Translation is a rewriting of an original text, and all rewritings, irrespectful of their intention, reflect a certain ideology and a poetics. Thus translation manipulates literature to function in a given way in a given society. On the other hand, the translators and the way they translate, translation policies and even the theories produced on translation are manipulated by certain facts, factors, ideology, politics and the likes of the readers in a certain way in a given society. In other words, the translators are not alone in the selection of texts as candidates to be represented in another culture; nor are they in the actual production of the rewriting. As André Lefevere puts it, "patrons circumscribe the translators ideological space, critics tend to circumscribe their poetological space [1, p.8]". Perrot d'Ablancourt talks about ideology when he states that in translation "he preferred what ought to be said or what he could say rather than what is actually said" [1, p.9]. For Horatius (Roman poet 65-8 B.C), the translators "thrive on the trust their patron and public put in them [1, p.14]".

Translation and translation studies need to be explored in connection with power and patronage, ideology and poetics. Ideology is often enforced by the patrons, the people or institutions who commission or publish translation. Early in history, translators tended to have relatively little freedom in their dealing with patrons, at least if they want to have their translations published. The "Lord" of the English translator John of Trevisa (1362-1412) states that he would have a skillful translation, that might be known and understood [1, p.20], thus limiting the capacity of the translator. Patrons of the time could encourage the publication of translations they considered acceptable and also prevent the publication of translations they did not consider so. Jean de Breche de Tours (French translator, 1514-1583) shares the same feelings with Philomon Holland (English translator 1552-1637) stating that his "translation of Hippocrates will attract the anger and the mockery of many who seem to be eager to keep the sciences hidden from the people" [1, p.22]. Du Bellay (French poet and translator 1552-1560) emphasizes the limitations of the translators' freedom at that time, in his statement "the obedience one owes (to patrons) admits of no excuse [1, p.19]." Publishers have taken the place of "princes and great lords," yet their influence on the shaping of translation cannot be underestimated.

When we move on to recent past we see that, with the industrial developments and

entailing social changes many other influences are included in the policy of selecting the texts to be translated. During the 60's and 70's literary translation was involved in reflecting different value systems and world views. Then the translation of literary works and especially of modern poetry attracted a great number of buyers and the sales was unprecedented. For Hughes, it reflected one aspect of the wave of mingled energies that galvanized those years with such extremes as Buddhism, the mass craze of Hippie ideology, the revolt of the young, the Pop music of the Beatles, and their generation [2, p.9]. Paul Engle sums up the cause of translation in the contemporary world: "As this world shrinks together....all people in all cultures move close together....and the crucial sentence may be, very simply TRANSLATE or DIE" [3, p.9].

With the changing and globalizing world, relatively smaller nations, speaking minor languages have become more dependent upon translation for their commercial, political and cultural survival. The Israeli scholars found themselves at a crossroads not only between the Soviet Union and the West but also between the Western and the Third World cultures. Thus in the 1980's Itamar Even-Zohar and Gideon Toury developed the Polysystem Theory in Translation, which presumes that the social norms and literary conventions in the receiving culture govern the aesthetic presuppositions of the translator and thus influence translation decisions [3, p.28]. Even-Zohar explores how texts to be translated are selected by the receiving culture, and claims that the selection is guided by some conditions in the receiving culture such as its compatibility with the new forms needed in the polysystem to achieve a complete and dynamic identity. Even-Zohar states three social circumstances which bring the translation to a primary position in a certain culture: 1) when a literature is "young" or in the process of being established, 2) when a literature is peripheral or weak, or both, 3) when a literature is experiencing a crisis [3, p.127]. In such conditions new translated texts serve as a medium through which new literary genres and values are imported. It means that the socio-literary conditions of the receiving culture partly determine the texts which are to be translated. With the polysystem theory extraliterary factors such as patronage, social conditions and institutional manipulation are related with how the texts to be translated are chosen in a literary system.

Translation scholars in England and America, for example Susan Bassnett, André Lefevere, David Lloyd and Maria Tymoczko, focus on institutions of prestige and power within any given culture and patterns in literary translation. Pavel Medvedev locates the literary system within the "ideological milieu" of an era [3, p.140]. According to Lefevere various subsystems in a society, including the literary , are all subject to a prevailing ideology characteristic of the society at a given point in history. He also introduces the term "refracted text" which means "texts that have been processed for a certain audience such as abridged versions of the classics for children and the TV [4, p.72]. In Germany during the Nazi period many texts by such writers as Heine and Schiller were refracted to conform to a specific ideology and poetics [3, p.140]. In order to investigate the ideological pressures, Lefevere also adds the concept of "patronage" by which he means "any kind of force that can be influential in encouraging and propagating, but also discouraging, censoring, and destroying works of literature". The patrons may be individuals, a religious body or a political party, as well as institutions such as publishing firms.

At this point we should deviate from the chronological order to see the effects of

social and political situation even on the production of translation theories: it is evident in the Deconstructionist approach which arose primarily in France in the 1960's during a time of social and political upheaval. Michel Foucault and the deconstructionists try to violate the traditional notions of the authorship, introducing the notion that the translator creates the original. They argue that original texts are constantly being rewritten and each translation reconstructs the source text. According to Foucault, the author's work is bound by the institutional systems of the time and place over which the individual author has little control or awareness.

In the nineties deconstruction strategies are challenged by the appearance of subgroups such as homosexuals, blacks, feminists and ethnic minorities. Rise of feminism has effects on the approaches to translation. In Canada a group of mostly feminists are researching political and theoretical problems of translation. Barbara Godard explores theoretical questions about the nature of language, woman's discourse and feminist translation in "Theorizing Feminist Discourse/Translation " [5].

Now there is a shift of focus in Translation Studies; it is considered as a cultural phenomena. Mary Snell Hornby from Germany proposes that translation scholars abandon their scientific attitude and move from "text" as a translation unit to culture [6, p.84]. Lefevere, while putting that all choices are circumscribed by power, argues that "neither ideology nor poetics, neither patronage nor rewriters are monolithic entities. Those who feel unhappy with the ideology and/or poetics of their own system will plan to use elements taken from the other system to further their own ends [3, p.190]".

As obvious , at the brink of the 21st century "translation" is not limited by the choices of the translators alone. Translators themselves, the text they choose to translate and the way they translate are all dependent upon the processes that shape a culture at a given point in time. These processes include economic, political and social factors.

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REFERENCES

1. *A. Lefevere.* Translation / History / Culture. London: Routledge, 1992.
2. *T. Hughes.* Introduction to Modern Poetry in Translation. New York: MPT/Persea, 1983.
3. *E. Gentzler.* Contemporary Translation Theories. London: Routledge, 1993.
4. *A. Lefevere.* "Translated Literature: Towards an Integrated Theory". Bull. Midwest, 14:1 (Spring), 1981, 68-78.
5. *B. Godard.* "Theorizing Feminist Discourse/Translation". Translation, History and Culture. Susan Bassnett - André Lefevere (eds.) London: Printer, 1990.
6. *M.S. Hornby.* "Linguistic Transcoding or Cultural Transfer? A Critique of Translation Theory in Germany". Translation, History and Culture. Susan Bassnett - André Lefevere (eds.) London: Pinter, 1990.

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N. Sharikadze

Genre Synthesis in Neo-Classical Music Theatre (on the examples of I. Stravinsky and D. Milhaud Operas)

Presented by Corr. Member of the Academy A. Gvakharia, May 11, 1998

ABSTRACT. **The present paper reports on various manifestations of genre synthesis in the first half of the 20th century. An opposition between genre synthesis and genre style in neo-classical music theatre is revealed.**

Key words: genre synthesis.

The process of seeking in opera genre which aims at renovation of genre by before used means was going on under the banner of synthesis. Thus synthesis in the 20th century became the typical tendency of opera genre. At the first half of the century numerous works were composed in which the elements of opera, oratorio, ballet, drama were mixed. It determines the formation of such type of music theatre, in which 'pure' genres are seldom met and the compositions themselves by their genre or stylistic peculiarities go beyond frames of one concrete genre or style, e. g. C. Debussy's mystery *Le martyre de Saint Sebastien*, A. Honegger's opera-oratorio *Antigone, Rex David,* A. Schoenberg's *Moses und Aaron,* I. Stravinsky's *Oedipus Rex,* melodrama *Persephone*. Dialectic interconnection most vividly reveals itself in genre synthesis, because they more or less preserve immanent drama peculiarities. It is especially actual in compositions of those composers who has neo-classical outlook. Genre synthesis determines the peculiarities of conflict dramaturgy of the following neo-classical operas, e.g. I. Stravinsky's opera-oratorio *Oedipus Rex* and melodrama *Persephone*.

From various variants of synthesis realization we single out only those types of genre synthesis, which are actual for conflict dramaturgy of the mentioned operas. They are: 1. The type of genre synthesis involved in conflict dramaturgy in which the equilibrium of genres taking part in synthesis is preserved. For instance, Stravinsky's *Oedipus Rex* can be given both as an opera and as an oratorio. While expressing the dramatic conflict in it genre element of opera and oratorio are so much brought together that it is impossible to separate them. Genre style of opera and oratorio is revealed in statics of scene action, in epic manner of conflict expression, activity of the narrator and choir. At the same time in the development of course-result scene, psychologization of hero (the action and contraction are projected just in it), dynamics of conflict development and aim. On the other hand, genre style of opera-oratorio comprises its compositional structure; speaker-choir-soloist testifies to the passionar tradition (narrator-choir-soloist), and the solution of scenic personages points to the opera-seria.

2. The type of genre synthesis involved in dramatic conflict in which genres taking part in synthesis are developed simultaneously. It is a unique manner and determines polyphony of synthetic genre [1], e. g. Stravinsky's melodrama *Persephone*. The genre of melodrama is lack of vivid crystal form, it has not individual compositional and structural regularity. In our opinion Stravinsky's attention to such free music scene form is natural,

because on the one hand, melodrama genre gives a unique possibility of creation musical synthetic composition, and on the other hand, mythological basis of melodrama offers opportunity to open the conflict idea in different stylistic planes. Thus the conflict of responsibility and feeling, man and fate is characterized by constantly changeable genre-stylistic background. In Stravinsky's creations genre-style-intonation are presented in dialectic unity, e. g. the characterization of Avmolp.

Based on melodrama genre Stravinsky creates such synthetic genre in which myth syncretism conditions dialogue between different cultures with account of genre or stylistic peculiarities of epochs.

If genre synthesis more or less implies the peculiarities of genre style, this last one can exist in conflict dramaturgy of monolithic opera, e. g. : D. Milhaud's opera *Les malheus d'Orphee* and Stravinsky's opera *The Rake's Progress*.

In conflict dramaturgy of the mentioned operas the genre style is determined by the work with model. Neo-classical idea of the restoration of remote past heritage is actual both for D. Milhaud and I. Stravinsky music theatre, although the principles of its realization are quite different. In conflict dramaturgy of monolithic operas two types of genre style can be singled out.

1. Genre and style properties of genre prototype while "modelling" lose direct connection with addresse and are expressed by assimilation, e. g. D. Milhaud's opera *Les malheus d'Orphee*.

Earlier the "restoration" of discrete structures of Italian opera determined the neglect of recitative as the most important vocal form of baroque opera and helps to concentrate on lyric part. The features of old Italian cantata are marked in mini opera: maximally concised scale and content single planness, maximal of characters. The principle of free use of genre or style components is characteristic for D. Milhaud. From this point of view the work with model is far from stylishness, i. e. the model is well concealed which differentiates Milhaud's and Stravinsky's neo-classicism. At the same time D. Milhaud's neo-classical music theatre feeding on contemporary fruitful soil makes the assimilation of earlier Italian opera and various forms of conventional theatre.

2. The type of modelling genre when modulation of genre style happens within one composition. It is based on principle of opposition, e. g. Stravinsky's opera *The Rake's Progress*. The development of conflict drama goes in parallel with opera-seria, peculiarities of lyric opera and at the same time preserves retrospectiveness [3], e. g. Buffoon action scene and romantic scene on cemetry.

Principle of modelling from one genre-stylistic layer to the second is similar to Eizenstein's method of " assembling" [4].

Genre and style express semantic function of musical language. In conflict dramatics of the mentioned operas the acting ability of genre synthesis and genre style determined neoclassicism as "cultural pluralism" of stylistic direction, which was taken by neoclassicism both in vertical and horizontal and synchronic and diachronic planes.

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REFERENCES

1. *V. Kholopova.* Muzyka kak vid iskustva. M., 1994 (Russian).
2. *L. Kokoreva.* Candidate Thesis M., 1984.
3. *A. Bateva.* J. Muzykalnyi sovremennik, 6, M., 1987.
4. *Idem.* Candidate Thesis M., 1983.

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