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Dear Colleagues,

The "Bulletin of the Georgian Academy of Sciences" is the leading scientific journal in Georgia. Since 1996 it's going to be published in Georgian and English.

The journal publishes mainly the articles featuring the results of research carried out in scientific institutions of Georgia.

Publication of the journal in English will make it possible to a foreign scientific community to get to know the up-to-date achievements in Georgian Science and at the same time, it'll give the chance to draw the scientists from the other countries to cooperate with our journal.

We hope that you, having subscribed to our journal, will assist in overcoming the difficulties, connected with its publication. We also hope that you'll use your authority and influence for popularization of the "Bulletin".

A. Tavkhelidze

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Z.Samsonia

On Closeness of Kernels of Potential Type Integral Equation

Presented by Corr.-Member of the Academy N.Vakhania, May 2, 1996

ABSTRACT. **The integral equations corresponding to potentials of double layer are considered along the boundaries of ε-close (in a certain sense), simply connected domains, belonging to a concrete Liapunov class.**

The order of closeness of kernels of the corresponding integral equations are established in respect to ε.

We denote by G a simply-connected domain involving the origin $z = 0$ and bounded with Liapunov conture $\Gamma \in C^1_\alpha\left(\frac{1}{2} < \alpha \le 1\right)$. We assume that the equation of the line Γ is given in parametric form

$$t = g(\tau)\ (0 \le \tau \le 2\pi).$$

Consider the integral equation

$$\nu(t_0) + \mathrm{Re}\frac{1}{\pi i}\int_\Gamma \frac{\nu(t)}{t - t_0}dt = f(t_0)\ \ (t_0 \in \Gamma), \tag{1}$$

where $f(t_0)$ is a real continuous function defined on the line Γ. It's well known, that integral equations of the type (1) are closely connected with Dirichlet problem, conformal mapping and other problems of applied character.

The given integral equation may be written in the following form

$$\nu(t_0) + \frac{1}{2\pi i}\int_\Gamma \frac{K(t,t_0)}{t'}\nu(t)dt = f(t_0),$$

where

$$K(t,t_0) = \frac{t'-t'_0}{t-t_0} + \frac{\overline{t'-t'_0}}{\overline{t-t_0}} + \frac{t'_0\dfrac{\overline{t'-t'_0}}{t-t_0} - \overline{t'_0}}{\overline{t-t_0}} \quad \left(t' = \frac{dt}{d\tau}\right). \tag{2}$$

Let $\widetilde{G}$ be a G-type domain, bounded with line $\widetilde{\Gamma}$, whose parametric equation is $t = \widetilde{g}(\tau)\ (0 \le \tau \le 2\pi)$. Besides the equation (1) we consider an integral equation of the type (1) corresponding to line $\widetilde{\Gamma}$

$$\widetilde{\nu}(t_0) + \mathrm{Re}\frac{1}{\pi i}\int_{\widetilde{\Gamma}} \frac{\widetilde{\nu}(t)}{t - t_0}dt = f(t_0), \tag{3}$$

where in the given case we mean $t_0 \in \widetilde{\Gamma}$.

Often instead of solving the equation (1) really we have to solve its "close" equation (3). In this connection it's important to estimate the difference between the solutions of equation (3) and desired one, which is essentially stipulated by closeness of kernels

$$K(t, t_0) = K(g(\tau), g(\tau_0)) \ (t, t_0 \in \Gamma)$$

and

$$\widetilde{K}(t, t_0) = K(\widetilde{g}(\tau), \widetilde{g}(\tau_0)) \ (t, t_0 \in \widetilde{\Gamma})$$

corresponding to these equations.

Definition. *We shall say that the domains G and $\widetilde{G}$ are ε-close domains, if the conditions*

$$\max_{\tau} |g(\tau) - \widetilde{g}(\tau)| \le \varepsilon, \ \|g'(\tau) - \widetilde{g}'(\tau)\|_{C_\alpha} \le \varepsilon, \tag{4}$$

hold, where $\|\cdot\|_{C_\alpha}$ denotes a norm in Hölder sense with index α.

According to this definition to each number $\varepsilon > 0$ there corresponds an infinite set of simply connected (close to G) domains, which afterwards we shall denote by $\mathcal{G}_\varepsilon$. Our aim is to study the question of closeness of indicated equations taking into account the conditions (4).

By proper change of the variable τ the corresponding integral equations may be written in the known form [1] respectively to the expression $\operatorname{ctg}\frac{\tau - \tau_0}{2}$. Afterwards our consideration will be based also on the estimation of [1], §5 which defines the condition of belonging the ratio of type $\frac{\psi(t) - \psi(t_0)}{|t - t_0|^\lambda}$ to the Hölder class. With this result taking into account the expressions (2) of $K(t, t_0)$ and its corresponding $\widetilde{K}(t, t_0)$, we reveal that the functions $K(g(t), g(t_0))$ and $K(\widetilde{g}(t), \widetilde{g}(t_0))$ belong (with respect to variables t, t_0) to Hölder class with certain index. The following proposition is valid.

Theorem. *If the domains G and $\widetilde{G} \in G_\varepsilon (0 < \varepsilon \le \varepsilon_0)$, whose boundaries belong to the class $C^1_\alpha (\frac{1}{2} < \alpha \le 1)$, are the ε-close domains in the sense* (4), *then the functions $K(g(\tau), g(\tau_0))$, $K(\widetilde{g}(\tau), \widetilde{g}(\tau_0))$ satisfy the Hölder condition with respect to variables τ, τ_0 with index $\delta = \min\{\alpha - \beta, \alpha + \beta - 1\} (\frac{1}{2} \le \beta < \alpha)$ and the estimate holds:*

$$\|K(g(\tau), g(\tau_0)) - K(\widetilde{g}(\tau), \widetilde{g}(\tau_0))\|_{C_\alpha} \le A(G; \beta)\varepsilon,$$

where the constant $A(G; \beta)$ and (small) ε_0 can be fully defined by giving the initial domain G.

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MATHEMATICS

S.Topuria

Generalized Derivatives and Boundary Properties of Differentiated Poisson Integrals for a Disk and a Half-Plane

Presented by Academician L.Zhizhiashvili, January 30, 1996

ABSTRACT. **Generalized derivatives and boundary properties of differentiated Poisson integrals for a disk and a half-plane are studied in this paper.**

In the present paper we prove theorems which supplement and generalize the corresponding Fatou's [1] and author's [2,3] investigations.

1. Notation and Definitions. We introduce the following notation: $R=(-\infty<x<\infty)$; $\widetilde{L}(R)$ is the set of measurable functions $f(x)$ such that $\frac{f(x)}{1+x^2}\in L(R)$; $R_2^+=\{(x,y)\in R_2;\ y>0\}$; $U(f;x,y)$ is the Poisson integral of the function $f(x)$ for a half-plane R_2^+, that is

$$U(f;x,y)=\frac{y}{\pi}\int_R\frac{f(t)dt}{(t-x)^2+y^2}.$$

Let $f\in L(-\pi;\pi)$, and let 2π be a periodic function, $f(r,x)$ be its Poisson integral for a disk

$$f(r,x)=\frac{1}{\pi}\int_{-\pi}^{\pi}f(t)P(r,t-x)dt,$$

where

$$P(r,t)=\frac{1}{2}\cdot\frac{1-r^2}{1-2r\cos t+r^2}.$$

The symbol $M(x,y)\xrightarrow{\Lambda}\mathcal{P}(x_0,0)(re^{ix}\xrightarrow{\Lambda}e^{ix_0})$ means that the point $M(re^{ix})$ tends to $\mathcal{P}(e^{ix_0})$ along a non-tangential to (circumference) path, i.e., there exists a positive number C, so that

$$\frac{x-x_0}{y}<C$$

($\frac{\rho}{1-r}<C$, ρ is a distance between the points re^{ix} and e^{ix_0}).

$M(x,y)\to\mathcal{P}(x_0,0)(re^{ix}\to e^{ix_0})$ means that the point $M(re^{ix})$ tends to $\mathcal{P}(e^{ix_0})$ remaining arbitrarily in the half-plane R_2^+ (inside the circle of radius I).

Assume [4] that the function $f(x)$ is defined in the neighbourhood of the point x_0 and that there exist constants $\alpha_0,\ \alpha_1,\ldots,\ \alpha_r$, such that for small

$$f(x_0+t)=\alpha_0+\alpha_1t+\ldots+\alpha_{r-1}\frac{t^{r-1}}{(r-1)!}+[\alpha_r+\varepsilon(t)]\frac{t^r}{r!},$$

where $\varepsilon(t)\to 0$, then $t\to 0$. They say that the function $f(x)$ has a generalized r-th derivative $f_{(r)}(x_0)$ at the point x_0, and by definition $f_{(r)}(x_0)=\alpha_r$. It is clear that $\alpha_0=f(x_0)$, $\alpha_1=f'(x_0)$. Moreover if there exists $f^{(r)}(x_0)$, then there also exists $f_{(r)}(x_0)$ and $f^{(r)}(x_0)=f_{(r)}(x_0)$. The converse is not true. The above given definition belongs to Peano.

We shall now cite the notion of a generalized symmetric derivative due to Valle-Poussin.

Let r be an odd number. If there exist constants $\beta_1, \beta_3,\ldots, \beta_r$, such that

$$\frac{f(x_0+t)-f(x_0-t)}{2}=\beta_1 t+\beta_3\frac{t^3}{3!}+\ldots+\beta_{r-2}\frac{t^{r-2}}{(r-2)!}+[\beta_r+\varepsilon(t)]\frac{t^r}{r!},$$

where $\varepsilon(t)\to 0$ as $t\to 0$, then β_r is said to be the r-th generalized symmetric derivative or more briefly the r -th symmetric derivative for f at the point x_0. Denote it by the symbol $f^*_{(r)}(x_0)$, i.e., $\beta_r=f^*_{(r)}(x_0)$. The same definition is given for the even r, with the only exception that the difference $f(x_0+t)-f(x_0-t)$ should be replaced by the sum $f(x_0+t)+f(x_0-t)$.

Obviously

$$\beta_1=\lim_{t\to 0}\frac{f(x_0+t)-f(x_0-t)}{2t},$$

$$\beta_0=f(x_0),\ \beta_2=\lim_{t\to 0}\frac{f(x_0+t)+f(x_0-t)-2f(x_0)}{t^2}.$$

It can be easily verified that from the existence of the derivatives $f_{(r)}(x_0)$ follows the existence of the derivatives $f^*_{(r)}(x_0)$ and their equality.

For the symmetric derivative from the existence of $f^*_{(r)}(x_0)$ follows $f^*_{(r-2)}(x_0)$, but $f^*_{(r-1)}(x_0)$ [4] should not be existed.

If there exist functions $\alpha_i(x)$, $i=0, 1,\ldots, r-1$ and such number α_r that there exist limits $\lim_{x\to x_0}\alpha_i(x)=\alpha_i$, $i=0, 1,\ldots, r-1$ and in the neighbourhood of the point x_0 for small

$$f(x+t)=\alpha_0(x)+\alpha_1(x)t+\ldots+\alpha_{r-1}(x)\frac{t^{r-1}}{(r-1)!}+[\alpha_r+\varepsilon(x,t)]\frac{t^r}{r!},$$

where $\lim_{(x,t)\to(x_0,0)}\varepsilon(x,t)=0$, then we say that the function has the generalized r-th derivative in a strong sense at the point x_0, and we define $\bar{f}_{(r)}(x_0)=\alpha_r$.

It is clear that $\alpha_0(x)=f(x)$, while

$$\alpha_1=\bar{f}_{(1)}(x_0)=\lim_{(x,t)\to(x_0,0)}\frac{f(x+t)-f(x)}{t}.$$

From the definition it follows that if there exists $\bar{f}_{(r)}(x_0)$, then there also exists $f_{(r)}(x_0)$, and they are equal.

Let us now give the definition of a generalized symmetric derivative in a strong sense. Let r be even. If there exist functions $\beta_{2i}(x)$, $i=0, 1, 2,\ldots,\frac{r-2}{2}$ and such number

β_r, that there exist limits $\lim_{x\to x_0}\beta_{2i}(x)=\beta_{2i}$, i=0,1,2,..., $\frac{r-2}{2}$, and in the neighbourhood of the point x_0 for small

$$\frac{f(x+t)+f(x-t)}{2}=\beta_0(x)+\beta_2(x)\frac{t^2}{2!}+\ldots+\beta_{r-2}(x)\frac{t^{r-2}}{(r-2)!}+\left[\beta_r+\varepsilon(x,t)\right]\frac{t^r}{r!},$$

where $\lim_{(x,t)\to(x_0,0)}\varepsilon(x,t)=0$, then we shall say that the function f has the r-th generalized symmetric derivative in a strong sense at the point x_0, and we define $\bar{f}^*_{(r)}(x_0)=\beta_r$.

The same definition is given for an odd r, but we should replace the sum $f(x+t)+f(x-t)$ by the difference $f(x+t)-f(x-t)$.

It is easily seen that from the existence of derivatives $\bar{f}_{(r)}(x_0)$ follows the existence of the derivatives $\bar{f}^*_{(r)}(x_0)$ and their equality.

Below we shall assume that $f\in\tilde{L}(R)$.

2. Boundary Properties of Differentiated Poisson Integrals.

The following theorems are valid:

Theorem 1. (a) *If at the point x_0 there exists a finite derivative $f^*_{(r)}(x_0)$, then*

$$\lim_{y\to 0+}\frac{\partial^r U(f;x_0,y)}{\partial x^r}=f^*_{(r)}(x_0).$$

(b) There exist continuous functions f, $g\in L(R)$, such that there exist $f^*_{(1)}(x_0)$ and $g^*_{(2)}(x_0)$, however the limit

$$\lim_{(x,y)\xrightarrow{\Lambda}(x_0,0)}\frac{\partial U(f;x,y)}{\partial x},\qquad \lim_{(x,y)\xrightarrow{\Lambda}(x_0,0)}\frac{\partial^2 U(g;x;y)}{\partial x^2}$$

does not exist.

Theorem 2. (a) *If at the point x_0 there exists a finite derivative $f_{(r)}(x_0)$, then*

$$\lim_{(x,y)\xrightarrow{\Lambda}(x_0,0)}\frac{\partial^r U(f;x,y)}{\partial x^r}=f_{(r)}(x_0).$$

(b) There exists a continuous function $f\in L(R)$ such that there exists $f_{(1)}(x_0)$, however the limit

$$\lim_{(x,y)\to(x_0,0)}\frac{\partial U(f;x,y)}{\partial x}.$$

does not exist.

Theorem 3. *If at the point x_0 there exists a finite derivative $\bar{f}^*_{(r)}(x_0)$, then*

$$\lim_{(x,y)\to(x_0,0)}\frac{\partial^r U(f;x,y)}{\partial x^r}=\bar{f}^*_{(r)}(x_0).$$

Corollary. *If at the point x_0 there exists a finite derivative $\bar{f}_{(r)}(x_0)$, then*

$$\lim_{(x,y)\to(x_0,0)} \frac{\partial^r U(f;x,y)}{\partial x^r} = \bar{f}_{(r)}(x_0).$$

The above given theorems are also valid for Poisson integral for a disk.

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MATHEMATICS

M.Bakuridze

Szász', Hardy's and Littlewood's Classes and Trigonometric Fourier Series

Presented by Academician L.Zhizhiashvili, April 5, 1995

ABSTRACT. **The paper deals with the theorems which establish some new properties of (c, α) $(-1 < \alpha \le 0)$ means of trigonometric Fourier series of functions from the Hardy's and Littlewood's and Szász classes**

I. Imply that $T = [-\pi, \pi]$, f is a real, 2π periodic function. If $f \in L(T)$, then by $\sigma[f]$ and $\overline{\sigma}[f]$ symbols are defined trigonometric Fourier series of function - f and conjugative series. By symbols $\sigma_n^\alpha(x, f)$ and $t_n^\alpha(x, f)$ there are defined means of Chezaro order $\alpha > -1$, also for $\sigma[f]$ and $\overline{\sigma}[f]$ series.

$$\sigma_n^\alpha(x, f) = \frac{1}{A_n^\alpha} \sum_{k=0}^{n} A_{n-k}^{\alpha-1} S_k(x, f)$$

$$t_n^\alpha(x, f) = \frac{1}{A_n^\alpha} \sum_{k=0}^{n} A_{n-k}^{\alpha-1} \overline{S}_k(x, f),$$

where $A_0^\alpha = 1$, $A_i^\alpha = \dfrac{(1+\alpha)\cdots(i+\alpha)}{i!}$, $\alpha > -1$

and $S_k(x, f)$ and $\overline{S}_k(x, f)$ are partial sums of $\sigma[f]$ and $\overline{\sigma}[f]$ series.

Let $p \in [1, +\infty]$. For function $f \in L^p(T)$, $(L^\infty(T) \equiv C(T))$ by symbol $\omega(\delta, f)_p$, $\delta \in]0, \pi[$ we define L^p modulus of continuousity.

Let

$$H_p^\omega \equiv \{f: \omega(\sigma; f)_p = O(\omega(\sigma))\},$$

where ω - modulus of continuousity [4].

It's necessary to say that if $\omega(\sigma) = \sigma^\alpha$, $\alpha \in]0, 1]$ then $H_p^\omega \equiv L_{ip}(\alpha, p)$ - is a class of Hardy and Littlewood.

If $p = +\infty$ then $H_\infty^\omega \equiv H^\omega \equiv \mathrm{Lip}\alpha$

Imply that $p \in]1, \infty]$. Szász's class is defined by

$$S_p = \left\{ f: \sum_{k=1}^{\infty} \frac{\omega\left(\frac{1}{k}, f\right)_p}{K^{1-1/p}} < \infty \right\}.$$

For $\mathrm{Lip}\alpha$, $\mathrm{Lip}(\alpha, p)$ S_p classes having properties of $\sigma_n^\beta(x, f)$ and $t_n^\beta(x, f)$ means are established (for different $\beta \in]-1, 0]$ by Zygmund [3], Hardy and Littlewood [7], Yano [8], L.V.Zhizhiashvili [2], P.L.Ulianov [6], A.I.Grigoriev [1].

II. This article uses theorems which have strengthening solutions of Hardy and Littlewood [7], P.L.Ul'yanov [6] and A.I.Grigoriev [1].

We should note that symbols A, $A(p)$, $A(\alpha)$, $A(p, \alpha)$ define positive constants which depend on the parameters.

Theorem 1. *Let* $\alpha\in]0, 1[$ *and* $\alpha p > 1$. *If* $f\in C(T)$ *then*

$$\left\|\bar{\sigma}_n^{-1}(f)-f\right\|_C \le A(p,\alpha)\left\{\omega\left(\frac{1}{n^{1-\alpha}}, f\right)_C + n^{\alpha}\omega\left(\frac{1}{n}, f\right)_p\right\}, \ n \ge 4$$

Theorem 2. *Let* $p\in]1, +\infty[$ *and function* $f\in C(T)$, *then,*

$$\left\|\sigma_n^{-1/p}(f)-f\right\|_C \le A(p)\left\{\omega\left(\frac{1}{n^{1-1/p}}, f\right)_C + n^{\frac{1}{p}}(\ln n)^{1-\frac{1}{p}}\omega\left(\frac{1}{n}, f\right)_p\right\}, \ n \ge 4$$

Theorem 3. *Assume that* $\alpha\in]0, 1[$ *and* $\varepsilon\in]0, 1/2[$. *If function* $f\in C(T)$ *and* $\alpha p = 1$, $\beta\in]0, \alpha[$, *then*

$$\left\|\sigma_n^{-\beta}(f)-f\right\|_C \le A(\alpha,\beta)\left\{\omega\left(\frac{1}{n^{1-\beta}}, f\right)_C + \omega^{1-2\varepsilon}\left(\frac{1}{n}, f\right)_C + \right.$$

$$\left. + n^{\alpha}\omega\left(\frac{1}{n}, f\right)_{\frac{1}{\alpha}} \omega^{\varepsilon(\alpha-\beta)}\left(\frac{1}{n}, f\right)_C\right\}.$$

For $\bar{\sigma}[f]$ series we make the following solution.

Theorem 4. *Let* α, β, ε, p *and function* f *satisfy conditions of theorem 3. Then*

$$\left\|t_n^{-\beta}(f)-\bar{f}_n\right\|_C \le A(\alpha,\beta)\left\{\omega\left(\frac{1}{n^{1-\beta}}, f\right)_C + \omega^{1-2\varepsilon}\left(\frac{1}{n}, f\right)_C + \right.$$

$$\left. + n^{\beta}\omega\left(\frac{1}{n}, f\right)_p \omega^{\varepsilon(\alpha-\beta)}\left(\frac{1}{n}, f\right)_C\right\}, \ n \ge 4$$

where

$$\bar{f}_n(x) = -\frac{1}{2\pi}\int_{\frac{\pi}{n}}^{\pi}[f(x+t)-f(x-t)]ctg\frac{t}{2}dt.$$

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ეროვნული ბიბლიოთეკა

MATHEMATICS

Z.Sanikidze

On Approximate Representation of One Integral Operator and its Application

Presented by Corr. Member of the Academy N.Vakhania, March 14, 1996

ABSTRACT. **An approximate scheme for solution of the integral equation (2) based on the certain approximation of the integral operator is considered. The question of the error estimation is studied.**

This paper reports estimation and approximation of operator of the form

$$(Ap)(\omega) \equiv \int_{-\omega_0}^{\omega_0} p(\tau)\cos(\omega-\tau)\ln tg\frac{|\omega-\tau|}{2}d\tau \qquad (1)$$

in the concrete functional space basing on a scheme of numerical solution of a certain type of integral equation.

The problem of interaction of two elastic bodies one with circular cylinder form and another having cut of the same form with radii r_1 and r_2 slightly differing from each other is reduced to the mentioned equation [1] of the type

$$(Bp)(\omega) \equiv 2(\theta_1 r_1 + \theta_2 r_2)\left[(Ap)(\omega) - \int_{-\omega_0}^{\omega_0} p(\tau)\cos\omega\cos\tau\ln tg\frac{|\tau|}{2}d\tau\right] -$$

$$-(æ_1 r_1 + æ_2 r_2)\int_{-\omega_0}^{\omega_0} p(\tau)\left[\sin|\omega-\tau| - \cos\omega\sin|\tau|\right]d\tau + 2\theta_1 r_1(1-\cos\omega)\int_{-\omega_0}^{\omega_0} p(\tau)d\tau =$$

$$= (r_2 - r_1)(1-\cos\omega),\ -\omega_0 < \omega < \omega_0\ (0 < \omega_0 < \frac{\pi}{2}), \qquad (2)$$

where θ_1, θ_2, $æ_1$, $æ_2$ are known constants. In this case the contact between the bodies caused by pressure is extended to the considerable part of their surfaces. It should be noted here that these and other similar problems have wide applications in engineering namely in so-called theory of sliding bearing [2].

The real calculation of the desirable (normal) pressure $P(\tau)$ summoned on the surface of contact is approximately possible on the base of numerical solution of the equation (2). In this connection the numerical scheme for solution of the equation (2) considered in the final part of the monography [1] is to be noted which is called (I.Shtaerman) a method of finite differences. The constructing of the scheme is materialized by approximation of the solution $p(\tau)$ by piece-wise constant function which finally reduces the given problem to the solution of certain linear equations system. The process scheme of the realization is considerably simplified by the fact that the integrals from the functions of $\cos(\omega - \tau)\ln tg\frac{|\omega-\tau|}{2}$ type can be directly computed.

In spite of some important problems connected with the approximate solution of the equation (2) further investigation is necessary. As the structural consideration of the function $p(\tau)$ shown in the neighbourhood of the interval endpoints $[-\omega_0, \omega_0]$ it may

have exponential (integrable) singularities. According to this it is more reasonable to construct and study such numerical schemes that stipulate possibly completely the structural properties of the desired function to which in its turn the questions of error estimation and the convergence of approximate process are strongly connected.

The aim of the scheme given below for the approximate solution of the equation (2) is to investigate and study some aspects of the mentioned questions. The scheme is based on the expression

$$p(\omega) = \frac{P_0(\omega)}{\sqrt{\omega_0^2 - \omega^2}} \quad (-\omega_0 < \omega < \omega_0) \tag{3}$$

of the solution p, where $p_0(\omega) \in H_{1/2}[-\omega_0, \omega_0]$ -satisfies the Holder's condition with index ½ on the segment $[-\omega_0, \omega_0]$ obtained due to transformations given in [1].

The construction of the corresponding scheme is based on the approximation of the function $p_0(\omega_0\tau)(-1 < \tau < 1)$ in the equation (2) taking into account the relation (3) after reducing the interval of integration to [-1, 1] by interpolative polynomial

$$L_{n-1}(P_0; \tau) = \sum_{k=1}^{n} C_k^{(n)}(\tau) P_0(\omega_0 \tau_k),$$

where

$$C_k^{(n)}(\tau) = \frac{(-1)^{k-1}\sqrt{1-\tau_k^2}\,T_n(\tau)}{n(\tau - \tau_k)},$$

$$T_n(\tau) = \cos(n \arccos\tau), \quad \tau_k = \cos\frac{2k-1}{2n}\pi .$$

Besides the corresponding functional coefficients

$$2(\theta_1 r_1 + \theta_2 r_2)\int_{-1}^{1} \frac{C_k^{(n)}(\tau)}{\sqrt{1-\tau^2}}\left[\cos(\omega_0\tau - \omega)\ln \operatorname{tg}\frac{|\omega_0\tau - \omega|}{2} - \right.$$

$$\left. - \cos\omega\cos(\omega_0\tau)\ln\operatorname{tg}\frac{\omega_0|\tau|}{2}\right]d\tau + (æ_1 r_1 + æ_2 r_2)\int_{-1}^{1}\frac{C_k^{(n)}(\tau)}{\sqrt{1-\tau^2}}[\cos\omega\sin\omega_0|\tau| -$$

$$- \sin|\omega_0\tau - \omega|]d\tau + 2\theta_1 r_1(1 - \cos\omega)\int_{-1}^{1}\frac{C_k^{(n)}(\tau)}{\sqrt{1-\tau^2}}d\tau$$

can be calculated by certain approximate formulae with given fortiori arbitrary accuracy.

Further estimates connected with given scheme are based on the study of the operator properties of equation (2) in Hölder space. Namely the inequality can be proved

$$\|Ap\|_{H_{1/2-\varepsilon}} \le C_0\|P_0\|_C, \tag{4}$$

for the respective characteristic operator (1) where $\|\cdot\|_C$ and $\|\cdot\|_{H_{1/2-\varepsilon}}$ denote the norms of continuous functions on $[-\omega_0, \omega_0]$ segment and those of Holder space (with index ½ - ε) respectively. ε is arbitrarily small positive number and the constant C_0 can be

found effectively. Applying the inequality (4) and taking into account the condition $P_0 \in H_{1/2}$ and the known estimates from the theory of interpolation [3], we get

$$\|B_0[P_0 - L_{n-1}(P_0; \tau)]\|_{H_{1/2-\varepsilon}} \le \frac{12C_0\omega_0(9+\frac{4}{\pi}\ln n)}{(n-1)^{1/2}}\|P_0\|_{H_{1/2}} \quad (n>1), \tag{5}$$

where $(B_0P_0)(\omega) = (B_P)(\omega)$.

The use of the relation (5) enables us to estimate effectively the error of the approximate solution P_0^* at the grid point $t_j = \omega_0\tau_j$ $(j = 1, 2, ..., n)$ on the base of the following inequality

$$|P_0(t_j) - P_0^*(t_j)| \le \max_m \left|R_n(t^{(m)})\right| \left|\sum_{m=1}^{q}\left|\sum_{p=1}^{n_m}\beta_{\nu_{pj}}^{(m)}\right|\right| +$$

$$+ \max_{\nu_p, m} \frac{\left|R_n(t_{\nu_p}^{(m)}) - R_n(t^{(m)})\right|}{\left|t_{\nu_p}^{(m)} - t^{(m)}\right|^{1/2-\varepsilon}} \sum_{m=1}^{q}\sum_{p=1}^{n_m}\left|\beta_{\nu_{pj}}^{(m)}\right|\left|t_{\nu_p}^{(m)} - t^{(m)}\right|^{1/2-\varepsilon}, \tag{6}$$

which in its turn can be obtained by modification of estimates given in monography [4] for Fredholm second kind integral equations with points t_j chosen in a certain way. $R_n(\tau) = P_0(\tau) - L_{n-1}(P_0, \tau)$ in the inequality (6) $\beta_{\nu_{pj}}^{(m)}$ are known values that can be calculated in the process of solution of the problem similar to the scheme given in [4]. The numbers $t_{\nu_p}^{(m)} \in \{t_k\}_{k=1}^{n}$ satisfy the condition $\max_{q,m}\left|t_{\nu_{n_q}}^{(m)} - t_{\nu_1}^{(m)}\right| \to 0$ $(n \to \infty)$ besides the natural numbers q and n_q as well as the points $t^{(m)} \in \left[t_{\nu_1}^{(m)}, t_{\nu_{n_q}}^{(m)}\right]$, can be defined according to the values $\beta_{\nu_{pj}}^{(m)}$.

We notice that the estimation of the constant $\|P_0\|_{H_{1/2}}$ involved in (5) after known values is connected with certain difficulties and requires proper individual approach. The estimation of such type in our case may be realized basing on some results given in [1] and [5].

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საქართველოს ეროვნული ბიბლიოთეკა

ეროვნული ბიბლიოთეკა

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MATHEMATICS

S.Zotniashvili

On the Extension of Selfadjoint Operators from Hilbert Spaces to Frechet-Hilbert Spaces

Presented by Corr. Member of the Academy N.Vakhania, July 18, 1996

ABSTRACT. **The paper deals with symmetric and selfadjoint operators in Hilbert and Frechet-Hilbert spaces. A sufficient condition for such operators defined on Hilbert spaces to be extendible as operators of the same kind to Frechet-Hilbert spaces is given.Moreover, the domains of definition of operators are extended essentially and in some cases the obtained operators are continuous although they were unbounded in the initial Hilbert spaces.**

The theory of selfadjoint operators is very important for the modern quantum mechanics and mathematical physics. The continuous selfadjoint operators in the Frechet-Hilbert spaces for the first time were defined and studied in [1-2] (the terminology is mainly used from [3]).Without requirement of continuity,these operators were defined in [4] for the projective limits of sequences of Hilbert spaces. It should be noted that the last spaces contain the classes of Frechet-Hilbert, nuclear Frechet and countable-Hilbert spaces. In [5] the extension of Ritz's method for the equation with positive definite operators in Frechet spaces was given.

Further we shall assume that the topology of the Frechet space is given by an increasing sequence of Hilbertian seminorms $\{\|\cdot\|_n\}$. This means that each $\|\cdot\|_n$ can be expressed by means of semiinner product $(.,.)_n$,i.e. for each $x\in E$ the equality holds $\|x\|_n = (x, x)_n^{1/2}$. Let $A: E \to E$ be a linear operator with a dense domain $D(A)$. If for $y\in E$ there exists an element $y^*\in E$ such that

$$(Ax, y)_n = (x, y^*)_n$$

for $x\in D(A)$ and $n\in N$, then by setting $A^*y = y^*$ we can define the operator $A^*: E \to E$ which is called the Hilbertian adjoint operator for A.The operator A^* is different from the usual topological adjoint operator A'. The above operator A is called symmetric if

$$(Ax, y)_n = (x, Ay)_n$$

for any $x, y\in D(A)$ and $n\in N$. Note that for symmetric operator A we have $D(A)\subset D(A^*)$, i.e. the Hilbertian adjoint A^* is an extension of A.

A symmetric operator is called selfadjoint if $A = A^*$, i.e. $D(A) = D(A^*)$.

A Frechet space E is called a Frechet-Hilbert space (a H-Frechet space according to the terminology of [1]), if its topology is generated by a sequence of Hilbertian seminorms $\|x\|_n = (x, x)_n^{1/2}$ $(n\in N)$ and the space E is complete in each seminorm topology. Therefore,in the case of Frechet-Hilbert space E the quotient spaces $E/\mathrm{Ker}\|\cdot\|_n$ are Hilbert spaces with the associated norms $\|\overset{\Lambda}{k_n}x\|_n = \|x\|_n$, where $k_n: E \to E/\mathrm{Ker}\|\cdot\|_n$ are canonical mappings. Inner product on $E/\mathrm{Ker}\|\cdot\|_n$ is defined by equality $\langle k_n x, k_n y\rangle_n = (x, y)_n$ and $\langle k_n x, k_n x\rangle_n^{1/2} = \|\overset{\Lambda}{k_n}x\|_n$ for each $x\in E$. Consequently, a Frechet-Hilbert space is the strict projective limit of a sequence of Hilbert spaces with respect to the canonical mappings

π_{nm}: $(E/\mathrm{Ker}\|\cdot\|_m, \|\hat{\cdot}\|_m) \to (E/\mathrm{Ker}\|\cdot\|_n, \|\hat{\cdot}\|_n)$ $(n \le m)$.

This means that each $x \in E$ can be represented as a sequence $\{k_n x\}$, where $\pi_{nm} k_m x = k_n x$ $(n \le m)$.

Examples of Frechet-Hilbert spaces are: the space of all sequences $\omega = C^N$, the space $\omega \times H$, where H is a Hilbert space, the Frechet spaces $(l^2)^N$ and $L^2_{loc}(x, \mu)$, where x is a locally compact space countable at infinity and μ is a Radon measure on x.

We now give a representation of Frechet-Hilbert space as the strict projective limit of a sequence of complemented Hilbert subspaces of it, and a representation of its strong dual as the strict inductive limit of the same sequence of its complemented Hilbert subspaces, which in the case of real Frechet-Hilbert spaces was proved in [3].

Theorem 1. *Let E be a nonnormable Frechet space with an increasing sequence of seminorms $\{\|\hat{\cdot}\|_n\}$ generating the topology. Then the following statements are equivalent*:

a) E is a Frechet-Hilbert space with the sequence of seminorms $\{\|\cdot\|_n\}$.

b) The strong dual space $(E', \beta(E', E))$ is the strict inductive limit of their increasing sequences of complemented subspaces spanned by the polar u_n° of the neighborhood $u_n = \{x \in E; \|x\|_n \le 1\}$.

c) For each $n \in N$ the space E is a topological sum of subspaces $\mathrm{Ker}\|\cdot\|_n$ and $(H_n, \|\cdot\|_{n,H_n})$, where $(H_n, \|\cdot\|_{n,H_n})$ is a Hilbert subspace of E with respect to the restriction $\|\cdot\|_{n,H_n}$ of $\|\cdot\|_n$ to H_n. In particular, E is the strict projective limit of the sequence $\{(H_n, \|\cdot\|_{n,H_n})\}$.

The proof of this theorem in the case of complex Frechet spaces does not differ essentially from the proof given in [3], as H_n and H_n' considered as the subspaces of E and E' coincide with each other, their norms are isometrical and inner products differ from each other as the inner products of complex Hilbert spaces and its dual.

From the Theorem 1 it follows that for each $n \in N$ the canonical mapping k_n is a projector of E onto H_n and its restriction on H_n is a topological isomorphism H_n onto $E/\mathrm{Ker}\|\cdot\|_n$. Therefore, each $x \in E$ can be represented as a sequence $\left\{ \overset{(n)}{x} \right\}$, where $\overset{(n)}{x}$ is a projection of x in H_n which we call the trace of x in H_n. Hence, for each $h_1, h_2 \in H_n$ the equalities are true

$$(h_1, h_2)_n = (h_1, h_2)_{n,H_n} = \langle k_n h_1, k_n h_2 \rangle_n, \tag{1}$$

where $(.,.)_{n,H_n}$ is a restriction of $(.,.)_n$ to H_n.

Let in notations of Theorem 1 A: $E \to E$ be a linear operator. Denote by A_n the projection of A on $E/\mathrm{Ker}\|\cdot\|_n$ defined on $D(A_n) = k_n(D(A))$ by the equality

$$A_n(k_n x) = k_n(Ax). \tag{2}$$

Denote also by $A^{(n)}$ the restriction of the operator A to H_n. If A is a symmetric operator, $D(A) \cap H_n$ is dense in H_n and H_n is an invariant subspace of A, i.e. $A(H_n) \subset H_n$, then according to (1) $A^{(n)}$ is a symmetric in H_n. It should be also noted that each symmetric operator in Hilbert space admits a sequence of invariant subspaces ([6], VII.2, Lemma 2).

Theorem 2. *Let E be a Frechet-Hilbert space which is a strict projective limit of the sequence of its subspaces $\{(H_n, \|\cdot\|_{n,H_n})\}$, $A: E \to E$ be a linear operator with a dense domain $D(A)$ and $A(H_n) \subset H_n$. Then the following statements hold:*

a) A is a symmetric operator in E if and only if A_n is a symmetric in a Hilbert space $(E/Ker\|\cdot\|_n, \|\hat{\cdot}\|_n)$ for each $n \in N$ with a dense domain $D(A_n) = k_n(D(A))$. Moreover, A is continuous operator belonging in $\mathcal{L}_0(E)$ (i.e. $\|Ax\|_n \le C_n\|x\|_n$ for each $n \in N$ and $x \in E$) and is selfadjoint in E if and only if A_n is symmetric and $D(A_n) = H_n$.

b) For each $h \in D(A) \cap H_n$

$$A_n(k_n h) = Ah = A^{(n)}h,$$

where A_n is defined by (2). Operator A is given on $D(A)$ by the equality

$$A\varphi = A\{\varphi_n\} = \{A_n\varphi_n\} = \{A^{(n)}\varphi_n\},$$

where $\varphi = \{\varphi_n\} = \{k_n\varphi\} \in D(A) \subset E$.

Let now $(H, \|\cdot\|)$ be a Hilbert space, $\{H_n\}$ be an increasing sequence of their subspaces such that $\bigcup_{n\in N} H_n = F$ is a dense in H. Let also $j_{nm}: H_n \to H_m$ $(n \le m)$, $j_n: H_n \to F$ $(n \in N)$ be identical embeddings, then $j_m \circ j_{nm} = j_n$ $(n \le m)$. If F is equipped with the inductive limit topology, then according to Theorem 1, the strong dual space $E = (F', \beta(F', F))$ is a Frechet-Hilbert space which can be represented as a strict projective limit of a sequence of Hilbert spaces $\{H_n'\}$ $(H_n' = H_n, n \in N)$ with respect to the adjoint mappings $j_{nm}': H_m' \to H_n'$ $(n \le m)$.

Theorem 3. *Let $(H, \|\cdot\|)$ be a Hilbert space, $\{H_n\}$ be an increasing sequence of their closed subspaces such that $\bigcup_{n\in N} H_n = F$ is dense in H, A be a symmetric operator in H, $A(H_n) \subset H_n$ and $A^{(n)}$ is restriction of A to H_n. If for $\varphi_m \in H_m$ the equalities $j_{nm}' A^{(m)}\varphi_m = A^{(n)} j_{nm}'\varphi_m (n \le m)$ are hold, then*

$$\widetilde{A}\varphi = \{A^{(n)}\varphi_n\},\ \varphi = \{\varphi_n\}$$

defines the symmetric operator on the Frechet-Hilbert space $E = (F', \beta(F', F))$.

For the illustration of Theorem 3 we apply it for the extension of the coordinate operator from the Hilbert space $L^2(R)$ onto Frechet-Hilbert space $L^2_{loc}(R)$. Let $H = L^2(R)$, then $H = L^2_0[-n, n]$ is the closed subspace of $L^2(R)$ of all functions which vanish almost everywhere outside $[-n, n]$, operators $j_{nm}: L^2_0[-n, n] \to L^2_0[-m, m]$ $(n \le m)$ and $j_n: L^2_0[-n, n] \to \bigcup_{n\in N} L^2_0[-n, n] = L^2_0(R) = F$ are identical embeddings and $Ax(t) = tx(t)$ is the coordinate operator defined in $L^2(R)$, $A^{(n)}$ is a restriction of the operator A on $L^2_0[-n, n]$. Obviously, $A(H_n) \subset H_n$ for each $n \in N$. Adjoint operators $j_{nm}': L^2_0[-m, m] \to L^2_0[-n, n]$ and $j_n': L^2_0(R)' = L^2_{loc}(R) \to L^2_0[-n, n]$ are restrictions on $[-n, n]$. The equalities $j_{nm}' A^{(m)}\varphi_m = A^{(n)} j_{nm}'\varphi_m$ $(n \le m)$ are valid and they show that the operations of restriction and multiplication by argument are commutative. Hence, by the equality

$$\widetilde{A}\varphi(t) = \{A^{(n)}\varphi_n\} = t\varphi(t),\ \varphi = \{\varphi_n\} \in L^2_{loc}(R)$$

the extension of the operator A from the Hilbert space $L^2(R)$ onto the whole space $L^2_{loc}(R)$ is defined. Moreover, according to the statement a) of the Theorem 2 we have $D(\widetilde{A}) = L^2_{loc}(R)$ and $\widetilde{A}$ is a selfadjoint continuous operator belonging to the class $\mathcal{L}_0(L^2_{loc}(R))$.

Theorem 3 also can be used for extension of selfadjoint differential operators L_∞, constructed in the papers [7-8].

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MATHEMATICS

M.Khabazi

On the Boundedness and Convergence of Partial Sums of Fourier Series in the Weighted Orlicz Classes

Presented by Academician L.Zhizhiashvili, August 22, 1996

ABSTRACT. **The necessary and sufficient condition is derived in order that a strong type weighted inequality be fulfilled in Orlicz classes for partial sums of trigonometrical Fourier series. Problems of covergense of Fourier series in Orlicz classes are also concidered.**

Let $f\in L^1(T)$ ($T=[-\pi, \pi)$ is the unit circle) and S_nf denote n-th partial sum of f's Fourier series. To avoid complications, S_nf will be assigned the value ∞ if f is not integrable. To formulate our results concerning the behaviour of S_nf, we need some definitions.

They say, that the weight function w (a. e. positive, integrable function on T) belongs to the Muckenhoupt's class A_p ($1 < p < \infty$), if there is a positive constant c, such that for every interval $I\subset T$

$$\left(\frac{1}{|I|}\int_I w(x)dx\right)\left(\frac{1}{|I|}\int_I \Big(w(x)\Big)^{-\frac{1}{p-1}}dx\right)^{p-1} \le c.$$

The following theorem was proved by R.Hunt, B.Muckenhoupt and R.Wheeden:

Theorem ([1], p.245). Let w be a weight function on T. Then the following statements are equivalent.

(i) $w\in A_p$.

(ii) There is a constant c, independent of f, such that for every f of period 2π,

$$\int_{-\pi}^{\pi}\Big|S_nf(x)\Big|^p w(x)dx \le c\int_{-\pi}^{\pi}\Big|f(x)\Big|^p w(x)dx,\ n=1,2,...$$

(iii) If f has period 2π and $\int_{-\pi}^{\pi}\Big|f(x)\Big|^p w(x)dx < \infty$ then

$$\lim_{n\to\infty}\int_{-\pi}^{\pi}\Big|f(x)-S_nf(x)\Big|^p w(x)dx = 0.$$

In this paper similar problems are investigated for $\varphi_w(L)$ classes. By Φ we shall denote the set of all functions φ: $R^1 \to R^1$ which are nonnegative, even and increasing on $(0, \infty)$ such that $\varphi(0+) = 0$, $\varphi(\infty) = \infty$. $\varphi_w(L)$ is the class of all measurable f functions for which $\int_{-\pi}^{\pi}\varphi\Big(f(x)\Big)w(x)dx < \infty$ ([2], [3]). As occurred, in many cases, the most important and interesting results, concerning functions from $\varphi_w(L)$ and

generalising classical theorems, are obtained when φ satisfies some extra conditions [4], [5], [6]. We mean the Δ_2 condition and the condition of quasiconvexity.

By definition the function φ satisfies the Δ_2 condition if there are $c > 0$ and $t_0 > 0$ such that

$$\varphi(2t) \le c\varphi(t), \quad t > t_0. \tag{1}$$

If (1) inequality holds for every $t > 0$, we say that φ satisfies the global Δ_2 condition.

A function ω is called a Young function on $[0, \infty)$ if $\omega(0) = 0$, $\omega(\infty) = \infty$, ω is convex and is not identically zero or ∞ on $(0, \infty)$; it may have a jump up to ∞ at some point $t > 0$, but in this case it should be left continuous at t.

A function φ is called quasiconvex if there exist a Young function ω and a constant $c>1$ such that

$$\omega(t) \le \varphi(t) \le \omega(ct) \quad t \ge 0. \tag{2}$$

If (2) inequality holds only when $t > t_0$, we shall say that φ is quasiconvex in a neighbourhood of ∞.

Now we are ready to formulate our results.

Theorem 1. Let w be a weight function on T and $\varphi\in\Phi$. Then the following statements are equivalent.

(i) φ^α is quasiconvex for some $\alpha\in(0, 1)$, φ satisfies the global Δ_2 condition and $\omega\in A_{p(\varphi)}$, where

$$\frac{1}{p(\varphi)} = \inf\{\alpha: \varphi^\alpha \text{ quasiconvex}\}.$$

(ii) There is a constant c, independent of f, such that for every $f\in\varphi_w(L)$

$$\int_{-\pi}^{\pi} \varphi\Big(S_n f(x)\Big) w(x)dx \le c \int_{-\pi}^{\pi} \varphi\Big(f(x)\Big) w(x)dx, \quad n=1,2,...$$

Theorem 2. Let w be a weight function on T and $\varphi\in\Phi$. If φ satisfies the Δ_2 condition, φ^α is quasiconvex in a neighbourhood of ∞ for some $\alpha\in(0, 1)$, and $\omega\in A_{q(\varphi)}$, where

$$\frac{1}{q(\varphi)} = \inf\{\alpha: \varphi^\alpha \text{ is quasiconvex in a neighbourhood of } \infty\}.$$

then

$$\lim_{n\to\infty} \int_{-\pi}^{\pi} \varphi\Big(f(x) - S_n f(x)\Big) w(x)dx = 0, \tag{3}$$

for every $f\in\varphi_w(L)$.

Theorem 3. Let w be a weight function on T and $\varphi\in\Phi$. If (3) holds for every $f\in\varphi_w(L)$, then φ satisfies the Δ_2 condition, φ is quasiconvex in a neighbourhood of ∞.

In case $w\equiv1$ these results were obtained by P. Oswald ([4]).

Finally we shall mention that theorems 1-3 are valid for Fourier-Vilenkin series also, L^p variants of which were proved by Wo-Sang Young [7].

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MATHEMATICS

T.Kadeishvili, S.Saneblidze

On a Multiplicative Model of a Fibration

Presented by Corr. Member of the Academy N.Berikashvili, February 1, 1996

ABSTRACT. **The paper reports the general algebraic situation when in a twisted tensor product strictly associative multiplication appears.**

After the work of E.Brown [1] the following problem has been naturally arosen: for a given fibration $F\to E\to X$, define an associative multiplication on the tensor product $(C^*(X)\otimes C^*(F), d_h)$ making it into a differential graded algebras (DGA) and modelling the singular cochain complex $C^*(E)$ of the total space E of the fibration. It appeared that this problem is not simple. Various multiplicative models were constructed where the associativity of multiplication was abolished (leading to an A_∞ - algebra structure), or a differential was not a derivation [2]. N.Berikashvili [3] has constructed a multiplicative model with associative multiplication when the fibre F is an Eilenberg-MacLane space and instead of $C^*(F)$ the cubical singular complex of F is taken in the Brown's model.

The aim of this paper is to describe general algebraic situation for formation twisted tensor products with associative multiplication.

Let A be a DGA with pairings $E_{1,k}$: $\otimes^{k+1} A\to A$, $E_{1,0}=id$, satisfying the following two basic conditions:

(i) If $E:\overline{B}A\otimes\overline{B}A\to A$ is a homomorphism defined by $E(a\otimes a_1|\ldots|a_k)=E_{1,k}$, $E_{0,1}=id$, and $E=O$ otherwise, then E is a twisting element ($\overline{B}A$ denotes the reduced bar-construction and $\overline{B}A\otimes\overline{B}A$ is the standard tensor coalgebra).

(ii) A coalgebra map $\overline{B}A\otimes\overline{B}A\to\overline{B}A$ induced by the twisting element E defines on $\overline{B}A$ an associative multiplication.

Let now B be a differential graded Hopf algebra and h: $B\to A$ be a twisting element. Then we have the following

Theorem 1. *By hypothesis above, let h: $B\to A$ be a twisting element such that an induced map $B\to BA$ is one of Hopf algebras. Then the twisted tensor product*

$$(A\otimes B, d_h),\ d_h=d^{\otimes}+h\cap,$$

becomes a DGA by the multiplication

$$\mu=(\mu_A\otimes\mu_B\otimes 1\otimes 1)T+$$
$$+\sum_{k>0}(\mu A\otimes\mu B)(1\otimes E_{1,k}\otimes 1\otimes 1)(1\otimes 1\otimes\nabla^k h\otimes 1\otimes 1)(1\otimes 1\otimes\nabla^k\otimes 1)(1\otimes T\otimes 1),$$

where T interchanges factors, ∇^k is the iterated coproduct, $\nabla^1=\nabla$: $B\to B\otimes B$.

Corollary 2. *By the hypothesis of the theorem the bar-construction BA of A becomes a DGA containing A and $\overline{B}A$ as sub-DGAs respectively.*

For $A\to C^*(X)$, a general method of construction of pairing (cochain operations) $\overline{B}A\otimes\overline{B}A\to A$ is given in [4] and a particular representative $E_{i,k}$ of such operations is due [5]. In this case, $E_{1,1}=\cup_1$ – Steenrod cochain operation, and $E_{1,k}$, $k>1$, are cochain homotopies estimating a deviation of $\cup_1$ from the Hirsh formulae (see (i)) and

associativity (see(ii)). Moreover, when B is the singular cubical complex of $K(\pi,n)$ then a twisting cochain of the theorem (as well as twisting product) is defined in [3].

For a commutative DGA A, we can assume that $E_{i,k}=0$ and then Proute's twisting element satisfies the hypothesis of the theorem [6].

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MATHEMATICS

G.Oniani, G.Lepsveridze

On the Differentiability of Integrals with Respect to Differential Bases Formed of Rectangles

Presented by Academician L.Zhizhiashvili, October 26, 1994

ABSTRACT. **Functions with integrals having various differential properties with respect to different bases $B_2(\theta)$ ($B_2(\theta)$ denotes basis formed of all rectangles having frame θ) are constructed. Moreover for constructing functions of mentioned types it is enough to take any function $f\in L\setminus L\ln^+L(I^2)$ and rearrange its meanings respectively.**

1. We shall call a frame in space $\mathbb{R}^2$ a set that consists of two interperpendicular lines passing the point $(0,0)$. We denote a frame by θ ($\theta=\{\theta^1, \theta^2\}$). Under θ_0 we shall assume the frame $\{OX^1, OX^2\}$, where OX^1 and OX^2 are the coordinate lines of space $\mathbb{R}^2$. Let's denote the set of all the frames of $\mathbb{R}^2$ by $\theta(\mathbb{R}^2)$.

We shall call a frame of rectangle $I\subset\mathbb{R}^2$ the frame $\theta=\{\theta^1,\theta^2\}$ for which the sides of I are parallel to the respective lines θ^i $(i=1,2)$ and we denote it by $\theta(I)$.

For a set $E\subset\theta(\mathbb{R}^2)$, $E\neq\varnothing$, we shall denote by $B_2(E)$ the differential basis for which $B_2(E)(x)$ $(x\in\mathbb{R}^2)$ consists of all the rectangles $I\subset\mathbb{R}^2$ with the features: $x\in I$, $\theta(I)\in E$. For $E=\{\theta\}$ we shall write simply $B_2(\theta)$ and in the case $\theta=\theta_0$-B_2. Let us agree here that for $E\subset\theta(\mathbb{R}^2)$, $E^*:=\theta(\mathbb{R}^2)\setminus E$.

We shall introduce the following metric into $\theta(\mathbb{R}^2)$: let θ_1, $\theta_2\in\theta(\mathbb{R}^2)$, $\theta_1=\{\theta_1^1,\theta_1^2\}$, $\theta_2=\{\theta_2^1,\theta_2^2\}$, then

$$\operatorname{dist}(\theta_1,\theta_2):=\min\{\widehat{(\theta_1^i,\theta_2^j)}: i,j=1,2\}, \tag{1}$$

where $\widehat{(\cdot,\cdot)}$ denotes the angle between the lines.

Let $V(\theta)$ be the set of all neighbourhoods of the frame $\theta\in\theta(\mathbb{R}^2)$; analogously, let $V(E)$ be the set of all the neighbourhoods of the set $E\subset\theta(\mathbb{R}^2)$.

For $\theta=\{\theta^1,\theta^2\}\in\theta(\mathbb{R}^2)\setminus\{\theta_0\}$ we shall consider the line θ^i $(i=1,2)$ lying, in the first and third quarters of the coordinate plane and let us define $\alpha(\theta)$ as the angle between the lines OX^1 and θ^i; let us $\alpha(\theta_0)$ be equal to 0.

Let us consider the space $[0,\pi/2)$ with the following metric: for α_1, $\alpha_2\in[0,\pi/2)$

$$\operatorname{dist}(\alpha_1,\alpha_2):=\min\{|\alpha_1-\alpha_2|, \pi/2-|\alpha_1-\alpha_2|\}. \tag{2}$$

It is clear that the mapping $\alpha:\theta(\mathbb{R}^2)\to[0,\pi/2)$ is an isometry of the space $\theta(\mathbb{R}^2)$ with metric (1) in space $[0,\pi/2)$ with metric (2). Let $|\cdot|_1$ be an ordinary Lebesgue measure on $[0,\pi/2)$. Now we shall define the measure $|\cdot|_{\theta(\mathbb{R}^2)}$ in the following way. We shall call the set $E\subset\theta(\mathbb{R}^2)$ $|\cdot|_{\theta(\mathbb{R}^2)}$-measurable if the set $\alpha(E)$ is $|\cdot|_1$-measurable assuming that $|E|_{\theta(\mathbb{R}^2)}:=|\alpha(E)|_1$.

2. Let $I^2:=(0,1)^2$ be the unit square. Let us agree to denote by $\Phi(L)(I^2)$ a set of all functions $f:\mathbb{R}^2 \to \mathbb{R}$ having the following qualities: $\operatorname{supp} f \subset I^2$, $\int_{I^2} \Phi(|f|) < \infty$. It's obvious, in studying the differentiableness of the integrals of the functions $f \in L(\mathbb{R}^2)$ we may limit ourselves to the consideration of the functions $f \in L(I^2)$.

It follows from the well-known theorem of Jessen-Marcinkiewitcz-Zygmund [1], [2] that if $f \in L\ln^+ L(I^2)$, then $\int f$ is differentiable with respect to $B_2(\theta)$ for every $\theta \in \theta(\mathbb{R}^2)$. On the other hand Marstrand [3] constructed such a function $f \in L(I^2)$, that $\int f$ is not differentiable with respect to $B_2(\theta)$ for every $\theta \in \theta(\mathbb{R}^2)$.

The question arises as to whether there generally exists a function $f \in L(I^2)$ such that $\int f$ is not differentiable with respect to $B_2(\theta_1)$ for some $\theta_1 \in \theta(\mathbb{R}^2)$ and $\int f$ is differentiable with respect to $B_2(\theta_2)$ for some other $\theta_2 \in \theta(\mathbb{R}^2)$. A positive answer was given to this in [4] where validity of the following theorems is proved.

Theorem 1^0. *There exists a function $f \in L(I^2)$, $f \geq 0$, such that*

(I) $\overline{D}_{B_2}\left(\int f, x\right) = \infty$ *a.e. on* I^2,

(II) *for every* $\theta \in \theta(\mathbb{R}^2) \setminus \{\theta_0\}$

$D_{B_2(\theta)}\left(\int f, x\right) = f(x)$ *a.e. on* I^2.

Theorem 2^0. *For every countable set $E \subset \theta(\mathbb{R}^2)$ there exists a function $f \in L(I^2)$, $f \geq 0$, such that*

(I) *for every* $\theta \in E$

$\overline{D}_{B_2(\theta)}\left(\int f, x\right) = \infty$ *a.e. on* I^2,

(II) *in the sence of measure* $|\cdot|_{\theta(\mathbb{R}^2)}$ *for a.e.* $\theta \in \theta(\mathbb{R}^2) \setminus E$

$D_{B_2(\theta)}\left(\int f, x\right) = f(x)$ *a.e. on* I^2,

3. We have obtained a generalization of the theorems 1^0 and 2^0 in two directions:

1) It was found that the functions from the theorems 1^0 and 2^0 can be obtained from every function $f \in L \setminus L\ln^+ L(I^2)$, $f \geq 0$, without changing its metrical qualities through corresponding rearrangement of its meanings;

2) Further more can be concluded about the differentiables of the integrals of the functions obtained in this way than it has been done in the theorems 1^0 and 2^0.

The following statement generalizes the theorems 1^0.

Theorem 1. *Let $f \in L \setminus L\ln^+ L(I^2)$, $f \geq 0$. Then there exists an equimeasurable of f function $g \in L(I^2)$ such that*

(I) $\overline{D}_{B_2}\left(\int g, x\right) = \infty$ *a.e. on* I^2,

(II) *for every* $V \in V(\theta_0)$, $V \neq \theta(\mathbb{R}^2)$

$D_{B_2(V^*)}\left(\int g, x\right) = g(x)$ *a.e. on* I^2.

The theorem cited below contains both theorem 1 and theorem 2^0.

Theorem 2. *Let* $f\in L\setminus L\ln^{+}L(I^2)$, $f\geq 0$. *Then for every no more than countable set* $E\subset\theta(\mathbb{R}^2)$ *and sequence* $V_k\in V(E)$, $V_k\neq\theta(\mathbb{R}^2)$ $(k\in\mathbb{N})$, *there exists an equimeasurable of* f *function* $g\in L(I^2)$ *such that*

(i) *for every* $\theta\in E$

$$\overline{D}_{B_2(\theta)}\left(\int g,x\right)=\infty \quad a.e.\ on\ I^2,$$

(ii) *for every* $k\in\mathbb{N}$

$$D_{B_2(V_k^*)}\left(\int g,x\right)=g(x) \quad a.e.\ on\ I^2.$$

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MATHEMATICS

G.Lepsveridze

On the Question of Strong Differentiability of Integrals Along Different Directions

Presented by Academician L.Zhizhiashvili, November 25, 1994.

ABSTRACT. **The theorem referring to the question of strong differentiation of integrals in various directions is given.**

Let $B = \{\mathbf{U}B(x): x \in \mathbf{R}^n\}$ be a differentiation basis in $\mathbf{R}^n$. For the function $f \in L_{loc}(\mathbf{R}^n)$ and every $x \in \mathbf{R}^n$ by $\overline{D_B}(\int f, x)$ and $\underline{D_B}(\int f, x)$ will be denoted upper and lower derivatives of the integral $\int f$ with respect to B at x respectively [1].

Let Y denote the set of n mutually orthogonal straight lines in $\mathbf{R}^n$ $(n \geq 2)$, which intersects at the origin. The union of such sets will be denoted by $\Gamma(\mathbf{R}^n)$. Elements of $\Gamma(\mathbf{R}^n)$ will be called directions.

Let Y be a fixed direction. By B_{2Y} we shall denote the differentiation basis consisting of all n - dimensional rectangles whose sides are parallel to straight lines from Y. If basis B_{2Y} differentiates the integral $\int f$ at a point x, then it is said, that $\int f$ is strongly differentiable at x along the direction Y (in the case Y - standard direction, then $\int f$ is strongly differentiable at x).

A.Zygmund had raised the following problem: for given function $f \in L(\mathbf{R}^2)$, it will always be possible to choose such direction Y, that $\int f$ will be strongly differentiable along Y almost everywhere [1].

Let $W(\mathbf{R}^n)$ $(n \geq 2)$ represent the class of all locally integrable functions f, for all of which the conditions $\overline{D_{B_{2Y}}}(\int f, x) = +\infty$ are fulfilled along to each fixed direction. Solving the problem of A.Zygmund, J.Marstrand [2] had shown that the class $W(\mathbf{R}^2)$ is not empty and with that he solved this problem negatively [3], [4].

In connection with the problem of A.Zygmund, in the paper [5] the following question had been considered: let this pair of different directions Y_1, and Y_2 be given. Does there exist a function $f \in L(\mathbf{R}^2)$ whose integral is strongly differentiable along the direction Y_1 a.e., but along Y_2 is strongly differentiable only on a set of zero measure? It is particularly established (see theorem 2 [5]) that for every sequence of directions $(Yn)_{n=1}^{\infty}$, there exists a nonnegative function $f \in L(\mathbf{R}^2)$, such that, for a.e. direction Y $(Y \neq Y_n, n = 1, 2, \ldots,)$ integral $\int f$ is strongly differentiable a.e. along Y, but for every fixed Y_n, $n = 1, 2, \ldots$, is strongly differentiable along Y_n only on a set of zero measure.

It is known [1], that if $\int |f|$ is strongly differentiable a.e., then the same is true for $\int f$. A.Papoulis [6] gave an example of function $f \in L(\mathbf{R}^2)$, for which $\int f$ is strongly differentiable a.e., but $\int |f|$ only on a set of zero measure. More strong result was obtained by T.S.Zerekidze [7]. For every function f from $W(\mathbf{R}^2)$, where a measurable function g exists, such that $|f| = |g|$ and $\int g$ is strongly differentiable a.e. along every fixed direction. In other words with changing the sign of function on the same set of positive measure, differential properties of integral may be improved in any fixed direction.

If we take above mentioned view into consideration, there arises a question if the following alternative holds:

Let $f \in W(\boldsymbol{R}^2)$ be given. After changing the sign of function on the same set of positive measure, differential properties of integral $\int f$ improves either in any direction or it does not improve in non of the directions.

The following theorem gives a negative answer to this question and strengthens the results of A.Papoulis [6] and J.Marstrand [2].

Theorem. *Let sequence of the directions* $(Yn)_{n=1}^{\infty}$ *be given. There exists a locally summable on* $\boldsymbol{R}^2$ *function f, such that*

1) *for almost every direction* Y $(Y \neq Y_n,\ n = 1, 2, \ldots,)$

$$D_{B_{2Y}}(\int f, x) = f(x) \text{ a.e.}$$

2) *for each direction* Y_n, $n = 1, 2, \ldots,$

$$\overline{D_{B_{2Y_n}}}(\int f, x) = +\infty \text{ a.e.}$$

3) $|f| \in W(\boldsymbol{R}^2)$.

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MATHEMATICAL PHYSICS

Academician T.Burchuladze, R.Rukhadze

Fourier Method in Three-Dimensional Boundary-Contact Dynamic Problems of Moment Elasticity Theory

Presented June 7, 1996

ABSTRACT. **The basic boundary-contact dynamic problems are considered for a three-dimensional piecewise-homogeneous isotropic medium with the central symmetry. Combining Fourier method with that of Laplace transform the posed problems are proved to be solvable in the classical sense under sufficiently general assumptions.**

Let $D_0 \in \mathbb{R}^3$ be a bounded domain limited by closed surfaces $S_0, S_1, \ldots, S_m$ of the class $\Lambda_2(\alpha)$, $0 < \alpha \leq 1$ [1], where S_0 involves all other S_k and the latters do not involve each other. We denote by D_k the bounded domain limited by S_k $(k = \overline{1,m})$, denote further $\overline{D}_0 = D_0 \cup (\bigcup_{k=0}^{m} S_k)$, $\overline{D}_k = D_k \cup S_k$ $(k = \overline{1,m})$; $L = (0, +\infty)$, $\overline{L} = [0, +\infty)$, $\Omega_k = D_k \times L$ (a cylinder in $\mathbb{R}^4$ $(k = \overline{0,m})$), $\overline{\Omega}_k = \overline{D}_k \times \overline{L}$.

The system of differential equations of moment elasticity theory for homogenous isotropic central symmetric medium has the form [1]

$$\begin{cases} (\mu+\alpha)\Delta u + (\lambda+\mu-\alpha)\operatorname{grad}\operatorname{div} u + 2\alpha \operatorname{rot}\omega + F^{(1)}(x,t) = \rho \dfrac{\partial^2 u}{dt^2}, \\ (\nu+\beta)\Delta\omega + (\varepsilon+\nu-\beta)\operatorname{grad}\operatorname{div}\omega + 2\alpha \operatorname{rot} u - 4\alpha\omega + F^{(2)}(x,t) = I \dfrac{\partial^2 \omega}{\partial t^2}, \end{cases} \tag{1}$$

where Δ is the three-dimensional Laplace operator, $u(x, t) = (u_1, u_2, u_3)$ is the displacement vector, $\omega(x, t) = (\omega_1, \omega_2, \omega_3)$ is the rotation vector, $F^{(1)}(x, t)$ is the vector of mass forces, $F^{(2)}(x, t)$ is the mass moment, ρ is the density of the medium, I is the inertia moment, λ, μ, α, ν, β, ε are elasticity constants.

The system (1) can be represented in a vector-matrix form

$$M(\partial_x)v(x, t) - r\frac{\partial^2 v(x,t)}{\partial t^2} = -F(x, t), \tag{2}$$

where $M(\partial_x)$ is a 6×6-dimensional matrix differential operator whose elements can be easily determined [1]; $F(x, t) = (F^{(1)}(x, t), F^{(2)}(x, t))$; $v(x, t) = (u(x, t), \omega(x, t)) = (u_1, u_2, u_3, \omega_1, \omega_2, \omega_3) = (v_1, v_2, \ldots, v_6)$; r is a 6×6-dimensional diagonal matrix: $r = \|r_{ij}\|_{6\times 6}$, where $r_{ij} = 0$ for $i \neq j$, $r_{ii} = \rho$ for $i = \overline{1, 3}$ and $r_{ii} = I$ for $i = 4, 5, 6$.

We will suppose that D_k $(k = \overline{0, m_0})$ is filled with a homogenous isotropic elastic medium with elasticity constants λ_k, μ_k, α_k, ν_k, β_k, ε_k and density ρ_k, and other D_k $(k = \overline{m_0 + 1, m})$ are empty.

In the case where in the operator $M(\partial_x)$ the constants λ, μ, α, ν, β, ε are substituted by λ_k, μ_k, α_k, ν_k, β_k, ε_k we will use the notation $\overset{k}{M}(\partial_x)$.

Denote

$$v^+(z,t) = \lim_{D_0 \ni x \to z \in S_k} v(x,t),\ k = \overline{0,m};$$

$$v^-(z,t) = \lim_{D_k \ni x \to z \in S_k} v(x,t),\ k = \overline{1,m_0}.$$

We will consider the first problem (other ones can be treated analogously).

Find in the cylinder Ω_k $(k = \overline{0,m_0})$ a regular vector $\overset{k}{v}(x,\ t)$ $(x \in D_k,\ t \in L,$ $\overset{k}{v} \in C^1(\overline{\Omega}_k) \cap C^2(\Omega_k))$ satisfying

1) the equation

$$\forall (x,t) \in \Omega_k:\ \overset{k}{M}(\partial_x)\overset{k}{v}(x,t) - \overset{k}{r}\frac{\partial^2 \overset{k}{v}(x,t)}{\partial t^2} = -\overset{k}{F}(x,t),\ k = \overline{0,m_0};$$

2) the initial conditions

$$\forall x \in \overline{D}_k:\ \lim_{t \to 0+} \overset{k}{v}(x,t) = \overset{k}{\varphi}(x),\ \lim_{t \to 0+} \frac{\partial \overset{k}{v}(x,t)}{\partial t} = \overset{k}{\psi}(x),\ k = \overline{0,m_0};$$

3) the contact conditions

$$\overset{o}{v}{}^+(z,t) - \overset{k}{v}{}^-(z,t) = \overset{k}{\Phi}(z,t),$$

$$\forall (z,t) \in S_k \times \overline{L}:\ \left(\overset{o\ o}{T}v(z,t)\right)^+ - \left(\overset{k\ k}{T}v(z,t)\right)^- = \overset{k}{\Psi}(z,t),\quad k = \overline{1,m_0},$$

where T is the strain operator of the moment elasticity theory [1];

4) the boundary conditions

$$\forall (z,t) \in S_k \times \overline{L}:\ \overset{o}{v}{}^+(z,t) = \overset{k}{f}(z,t),\ k = 0,\ m_0 + 1,\ \ldots,\ m.$$

It is convenient to denote the posed problem by $(\mathrm{I})_{F,\varphi,\psi,\Phi,\Psi,f}$. Assume that the given vector functions $\overset{k}{F}$, $\overset{k}{\varphi}$, $\overset{k}{\psi}$, $\overset{k}{\Phi}$, $\overset{k}{\Psi}$, $\overset{k}{f}$ satisfy the following conditions:

1. $\overset{k}{F}(\cdot,\cdot) \in C^2(\overline{\Omega}_k)$ and the third order derivatives belong to $L_2(D_k)$, $k = \overline{0,m_0}$.

Moreover

$$\overset{o}{F}\Big|_{S_k} = 0,\ k = 0,\ m_0 + 1,\ \ldots,\ m;\ t \in L,$$

$$\overset{o}{F}{}^+ = \overset{k}{F}{}^-,\ (\overset{o\ o}{T}F)^+ = (\overset{k\ k}{T}F)^-,\ (\overset{o\ o}{M}F)^+ = (\overset{k\ k}{M}F)^-,\ k = \overline{1,m_0},\ t \in \overline{L}.$$

2. $\overset{k}{\varphi} \in C^3(\overline{D}_k)$, and the fourth order derivatives belong to $L_2(D_k)$. Moreover,

$$\overset{o}{\varphi}\Big|_{S_k} = \overset{o\ o}{M}\varphi\Big|_{S_k} = 0,\ k = 0,\ m_0 + 1,\ \ldots,\ m;$$

$$\overset{o}{\varphi}{}^{+} = \overset{k}{\varphi}{}^{-},\ (\overset{o}{T}\overset{o}{\varphi})^{+} = (\overset{k}{T}\overset{k}{\varphi})^{-},\ (\overset{o}{M}\overset{o}{\varphi})^{+} = (\overset{k}{M}\overset{k}{\varphi})^{-},$$
$$(\overset{o}{T}\overset{o}{M}\overset{o}{\varphi})^{+} = (\overset{k}{T}\overset{k}{M}\overset{k}{\varphi})^{-},\ k = \overline{1, m_0}.$$

3. $\overset{k}{\psi} \in C^2(\overline{D}_k)$, and the third order derivatives belong to $L_2(D_k)$. Moreover,

$$\overset{o}{\psi}\Big|_{S_k} = \overset{o}{M}\overset{o}{\psi}\Big|_{S_k} = 0,\ k = 0,\ m_0 + 1,\ \ldots,\ m;$$
$$\overset{o}{\psi}{}^{+} = \overset{k}{\psi}{}^{-},\ (\overset{o}{T}\overset{o}{\psi})^{+} = (\overset{k}{T}\overset{k}{\psi})^{-},\ (\overset{o}{M}\overset{o}{\psi})^{+} = (\overset{k}{M}\overset{k}{\psi})^{-},$$
$$(\overset{o}{T}\overset{o}{M}\overset{o}{\psi})^{+} = (\overset{k}{T}\overset{k}{M}\overset{k}{\psi})^{-},\ k = \overline{1, m_0}.$$

4. $\forall t \in \overline{L}: \dfrac{\partial^p}{\partial t^p}\overset{k}{\Phi}(\cdot,\ t) \in C^2(S_k),\ p = \overline{0,7};$

$$\forall z \in S_k:\ \overset{k}{\Phi}(z,\cdot) \in C^7(\overline{L}),\ \left(\frac{\partial^n \overset{k}{\Phi}(z,t)}{\partial t^n}\right)_{t=0} = 0,\ n = \overline{0,5};\ k = \overline{1, m_0}.$$

5. $\forall t \in \overline{L}: \dfrac{\partial^p}{\partial t^p}\overset{k}{\Psi}(\cdot,\ t) C^1(S_k),\ p = \overline{0.7};$

$$\forall z \in S_k:\ \overset{k}{\Psi}(z,\cdot) \in C^7(\overline{L}),\ \left(\frac{\partial^n \overset{k}{\Psi}(z,t)}{\partial t^n}\right)_{t=0} = 0,\ n = \overline{0,5};\ k = \overline{1, m_0}.$$

6. $\forall t \in \overline{L}: \dfrac{\partial^p}{\partial t^p}\overset{k}{f}(\cdot,\ t) \in C^2(S_k),\ p = \overline{0.7};$

$$\forall z \in S_k:\ \overset{k}{f}(z,\cdot) \in C^7(\overline{L}),\ \left(\frac{\partial^n \overset{k}{f}(z,t)}{\partial t^n}\right)_{t=0} = 0,\ n = \overline{0,5};$$
$$k = 0,\ m_0 + 1,\ \ldots,\ m.$$

7. The moduli of $\overset{k}{F}(x,\ t)$, $\overset{k}{\Phi}(x,\ t)$, $\overset{k}{\Psi}(x,\ t)$, $\overset{k}{f}(x,\ t)$ and all their existing derivatives are less than $c\cdot\exp(\sigma_0 t)$ for large t, where c and σ_0 are positive constants.

The uniqueness of the posed problem is proved in [2].

Represent the solution of the problem $(\mathrm{I})_{F,\varphi,\psi,\Phi,\Psi f}$ as the sum of the solutions of the problems $(\mathrm{I})_{0,0,0,\Phi,\Psi f}$ and $(\mathrm{I})_{F,\varphi,\psi,0,0,0}$. Under the conditions given above, the existence of a regular solution of the problem $(\mathrm{I})_{0,0,0,\Phi,\Psi f}$ follows from the results of [2].

The existence of a regular solution of the problem $(\mathrm{I})_{F,\varphi,\psi,0,0,0}$ is proved using the Fourier method. If we apply the formal scheme of the Fourier method to the problem $(\mathrm{I})_{F,\varphi,\psi,0,0,0}$ we get

$$\overset{k}{\tilde{v}}(x,\ t) = \sum_{n=1}^{\infty} \overset{k}{w}{}^{(n)}(x)\left(\tilde{\varphi}_n \cos\sqrt{\gamma_n}\,t + \frac{\tilde{\psi}_n}{\sqrt{\gamma_n}}\sin\sqrt{\gamma_n}\,t\right) +$$

$$+\sum_{n=1}^{\infty} \overset{k}{w}{}^{(n)}(x)\frac{1}{\sqrt{\gamma_n}}\int_0^t \widetilde{F}_n(\tau)\sin\sqrt{\gamma_n}(t-\tau)d\tau, \qquad (3)$$

where $\overset{k}{\widetilde{v}}(x,\ t) = \overset{k}{æ}\,\overset{k}{v}(x,\ t)$, $\overset{k}{æ} = \|\overset{k}{æ}_{ij}\|_{6\times 6} = \left\|\sqrt{\overset{k}{r}_{ij}}\right\|_{6\times 6}$; $\widetilde{\varphi}_n$, $\widetilde{\psi}_n$, $\widetilde{F}_n$ are the Fourier coefficients with respect to the system $\left(\overset{k}{w}{}^{(n)}(x)\right)_{n=1}^{\infty}$ of the functions $\overset{k}{\widetilde{\varphi}}(x) = \overset{k}{æ}\,\overset{k}{\varphi}(x)$, $\overset{k}{\widetilde{\psi}}(x) = \overset{k}{æ}\,\overset{k}{\psi}(x)$ and $\overset{k}{\widetilde{F}}(x,\ t) = \overset{k}{æ}{}^{-1}\overset{k}{F}(x,\ t)$ respectively; $(\gamma_n)_{n=1}^{\infty}$ are the eigenvalues and $\left(\overset{k}{w}{}^{(n)}(x)\right)_{n=1}^{\infty}$ the corresponding regular orthonormalized in $L_2\left(\bigcup_{k=0}^{m_0} D_k\right)$ eigenfunctions of the problem

$$\forall x\in D_k:\ \overset{k}{\widetilde{M}}(\partial_x)\overset{k}{w}(x) + \gamma\overset{k}{w}(x) = 0,\ k = \overline{0, m_0},$$

$$\forall z\in S_k:\ \overset{o}{w}{}^{+}(z) = \overset{k}{w}{}^{-}(z),\ \left(\overset{o}{\widetilde{T}}\,\overset{o}{w}(z)\right)^{+} = \left(\overset{k}{\widetilde{T}}\,\overset{k}{w}(z)\right)^{-},\ k = \overline{1, m_0},$$

$$\forall z\in S_k:\ \overset{o}{w}{}^{+} = 0,\ k = 0,\ m_0 + 1,\ \ldots,\ m,$$

where $\overset{k}{\widetilde{M}}(\partial_x) = \overset{k}{æ}{}^{-1}\overset{k}{M}(\partial_x)\overset{k}{æ}{}^{-1}$, $\overset{k}{\widetilde{T}} = \overset{k}{æ}{}^{-1}\overset{k}{T}\overset{k}{æ}{}^{-1}$

It is proved that the system $\left(\overset{k}{w}{}^{(n)}(x)\right)_{n=1}^{\infty}$ is complete in $L_2\left(\bigcup_{k=0}^{m_0} D_k\right)$. By the use of a method analogous to that given in [3], it is proved that (3) is in fact a regular (classic) solution of the problem $(\mathrm{I})_{F,\varphi,\psi,0,0,0}$.

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E.Puladze, Z.Abashidze

Problem of Elasticity and Plasticity for the Plate Weakened by Two Holes

Presented by Academician T.Burchuladze, June 17,1996

ABSTRACT. **We consider the problem of elasticity and plasticity for inifinite plate weakened by two identical holes, when the region of plasticity envolves only contours of holes. We construct the solutions and get the equation of unknown contours of the holes when the plate is stretched by the main stresses effecting infinity and a constant normal force effects unknown contours of the holes.**

Let's consider homogeneous, isotropic infinite plate weakened by two identical holes with smooth contours. Let's consider the case when the region S occupied by the plate in the complex plane $z=x+iy$ is symmetric in respect to OX and OY axes. Without lost of the generality we suppose that holes are symmetric in respect to OY axes (*Fig.*). We denote by L_1 and L_2 the contours of holes.

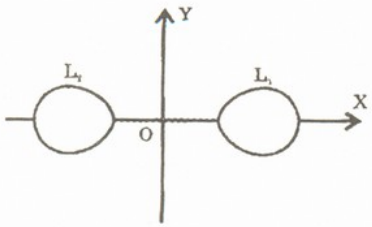

Fig.

Assume the plate is stretched by the main stress effecting infinity

$$\sigma_x^{\infty}=A,\ \sigma_y^{\infty}=B,\ \tau_{xy}^{\infty}=0. \tag{1}$$

The normal constant stress effects contours of holes and the tangent stress is zero.

$$\sigma_n=-p,\ \tau_{ln}=0,\ t\in L, \tag{2}$$

where $L=L_1\cup L_2$.

Let's consider the following problem. Determine the shape of holes contours and the stressed condition when the contour L is plastic and is not spread inside the plate [1]

$$(\sigma_t-\sigma_n)^2+4\tau_{tn}^2=4k^2, \tag{3}$$

where σ_t is tangential normal stress. In this case the Kolosov - Muskhelishvili complex potentials satisfy the conditions.

$$\Phi(z)=\frac{A+B}{4}=\frac{k-p}{2},\ z\in S, \tag{4}$$

$$e^{2i\alpha(t)}\Psi(t)=b,\ b=\frac{A+B}{2}+p,\ t\in L, \tag{5}$$

$\alpha(t)$ is an angle between OX axis and outer normal of the contour L.

The problems of elasticity and plasticity of unknown contours for the plates weakend by holes are solved by several authors [2,3].

At the infinitely remote point

$$\Psi(\infty)=\frac{B-A}{2}. \tag{6}$$

Region S is symmetric in respect to coordinate axes and if we take into account the symmetry of the stress, we can easily ascertain that $\Psi(z)$satisfies the equality

$$\Psi(z)=\Psi(-z). \tag{7}$$

Let's consider the part S_1 of region $S\text{-}S_1=S\cap\{z: Rez\geq 0\}$ because of (5),(6) the function $\Psi(z)$, which is analytic in region S_1, on the boundary of this region satisfies the following conditions

$$e^{2i\alpha(t)}\Psi(t)=b,\ t\in L_i, \tag{8}$$

$$\Psi(t)=\Psi(-t),\ Ret=0. \tag{9}$$

Let's denote by D the outer region of the unit circle of ζ plane $|\zeta|=1$ cut across the part of real line $|\zeta|\geq c\ (c>1)$.

Let the function $z=-i\sqrt{\omega(\zeta)}$ be conformal map of the region S_1 onto region D. $\omega(\zeta)$ is analytic in region $|\zeta|>1$, $\omega(c)=0$ and at the infinitely remote point has the form

$$\omega(\zeta)=R\zeta+O(\zeta^{-1}),\ R>0. \tag{10}$$

Because of (9) on the section of ζ plane we have

$$\Psi_0^+(\zeta)=\Psi_0^-(\zeta),\ \text{where } \Psi_0(\zeta)=\Psi(\omega(\zeta)). \tag{11}$$

It means, that the function $\Psi_0(\zeta)$ is analytic in region $|\zeta|>1$. In our case for $e^{2i\alpha}$ we will have [2]:

$$e^{2i\alpha(t)}=-\frac{\sigma^2\omega'(\sigma)}{\sqrt{\omega(\sigma)}}\cdot\frac{\overline{\sqrt{\omega(\sigma)}}}{\overline{\omega'(\sigma)}},\ |\sigma|=1, \tag{12}$$

and the condition (8) turns into the form

$$\frac{\sigma^2\omega'(\sigma)}{\sqrt{\omega(\sigma)}}\Psi_0(\sigma)=-b\frac{\overline{\omega'(\sigma)}}{\overline{\sqrt{\omega(\sigma)}}},\ \sigma\in l, \tag{13}$$

where l is $|\zeta|=1$ circle.

Rewrite equality (13) as following

$$\sigma^2\omega'(\sigma)\Psi_0(\sigma)\sqrt{\frac{\sigma-c}{\omega(\sigma)}}\cdot\overline{\sqrt{\sigma-c}}=-b\overline{\omega'(\sigma)}\sqrt{\frac{\overline{\sigma-c}}{\omega(\sigma)}}\sqrt{\sigma-c}, \tag{14}$$

$\zeta=c$ is the only point of region $|\zeta|>1$, where $\omega(\zeta)=0$, so $\sqrt{\frac{\zeta-c}{\omega(\zeta)}}$ is analytic in this region.

Introduce the function

$$W(\zeta)=\begin{cases}-b\overline{\omega'(1/\bar{\zeta})}\sqrt{\overline{\frac{1}{\bar{\zeta}}-c\Big/\omega\left(\frac{1}{\bar{\zeta}}\right)}}\cdot\sqrt{\zeta-c} & |\zeta|<1\\ \zeta^2\Psi_0(\zeta)\omega'(\zeta)\sqrt{\frac{\zeta-c}{\omega(\zeta)}}\sqrt{\overline{\frac{1}{\bar{\zeta}}-c}}; & |\zeta|>1\end{cases} \tag{15}$$

$W(\zeta)$ is analytic inside and outside of unit circle because (14) satisfies the condition

$$W^+(\sigma)=W^-(\sigma),\ \sigma\in l \tag{16}$$

and so W is analytic in hole ζ plane. From (6), (10), (15) we get that the function $W(\zeta)$ has the pole of second order at the infinitely remote point. Finally from extended Liuvil's theorem we have [3]:

$$W(\zeta)=C_0+C_1\zeta+C_2\zeta^2. \tag{17}$$

From equations (15),(17) we easily get

$$z=-i\sqrt{\omega(\zeta)}=\frac{i}{2b}\int_1^{\zeta}\frac{\left(\overline{C_0}+\overline{C_1}/\zeta+\overline{C_2}/\zeta^2\right)d\zeta}{\sqrt{\zeta-c}\sqrt{\frac{1}{\zeta}-c}}+A_1, \tag{18}$$

where A_1 is constant and can be calculated from condition $\omega(c)=0$. For C_0 and C_2 we have

$$C_0=\lim_{\zeta\to 0} W(\zeta)=-ib\sqrt{RC}\,,$$

$$C_2=\lim_{\zeta\to\infty}\frac{W(\zeta)}{\zeta^2}=i\cdot\frac{B-A}{2}\sqrt{RC}\,.$$

For determining the constant C_1 let's use only condition for mapping function, which has the form

$$\int_{\gamma}\frac{\left(\overline{C_0}+\overline{C_1}/\zeta+\overline{C_2}/\zeta^2\right)d\zeta}{\sqrt{\zeta-c}\sqrt{1/\zeta-c}}=0,$$

where γ is any closed curve completely placed in region $|\zeta|>1$ having no common point with the section.

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Z.Abashidze

Problem of Elasticity and Plasticity for the Square Plate Weakened by the Hole with Partially Unknown Boundary

Presented by Academician T.Burchuladze, April 18, 1996

ABSTRACT. **We consider a problem of elasticity and plasticity for the square plate which is weakened by square hole with rounded off vertexes. Region of plasticity contains only unknown rounded part of the hole contour and isn't spread inside the plate. We contract solutions and get equation of unknown part of the hole contour when the normal displacement is constant on the linear parts of the boundary and there is no normal stress on unknown part of the hole contour.**

Let's consider homogeneous, isotropic square plate which is weakened by the square hole. The contour of hole is rounded off at the vertexes and is unknown part of the boundary of the plate. Denote this by l_0, the other part of boundary of hole is a known curve and denote it by L_0. Denote also by L_1 the outer boundary of the plate.

Let S be the region of a complex $z=x+iy$ plane which is occupied by our plate so that the linear parts of square are parallel to OX and OY axes and the plate is symmetric in respect of this axes.

Let the plate be under stressed condition so that the normal displacement is zero on the curves L_1 and L_0 and the tangent stress is zero too.

$$U_n = \text{const},\ \tau_{tn}=0,\ t\in L_1\cup L_0. \tag{1}$$

There is no normal stress on contour l_0 and the tangent stress is also zero on l_0.

$$\sigma_n=0,\ \tau_{tn}=0,\ t\in l_0. \tag{2}$$

Let's consider the following problem. Determine a shape of unknown part of the hole contour and stressed condition of the plate when the contour l_0 is in plastic condition which doesn't spread inside the plate [1].

$$(\sigma_t-\sigma_n)^2+4\tau_{tn}^2=4k^2,\ t\in l_0, \tag{3}$$

where σ_t is tangential normal stress.

On the basis of well-known Kolosov-Muskhelishvili formulae [2] we easily obtain the following:

$$\sigma_n+i\tau_{tn}=\Phi(z)+\overline{\Phi(z)}-e^{-2i\alpha(t)}(z\overline{\Phi'(z)}+\overline{\Psi(z)}), \tag{4}$$

$$2\mu(u_t'-iu_n')=æ\Phi(z)-\overline{\Phi(z)}+e^{-2i\alpha(t)}(z\overline{\Phi'(z)}+\overline{\Psi(z)}), \tag{5}$$

where $\alpha(t)$ is angle between OX axis and outer normal of contour at the point t.

Because of symmetry of the plate the normal displacement and the tangent stress will be zero on those parts of OX and OY axes inside of S region. So it is sufficient to consider the line drawn part of region S (Fig.) which we denote by D.

From (1) - (5) it follows that the Kolosov-Muskhelishvili complex potentials satisfy the conditions.

$$\Phi(z)=a,\ z\in S,\ a=\frac{k}{2}, \tag{6}$$

$$e^{2i\alpha(t)}\Psi(t)=b,\ t\in l_0',\ b=k. \tag{7}$$

$$\mathrm{Im}\,e^{2i\alpha(t)}\Psi(t)=0,\ t\in L', \tag{8}$$

where l_0' is part of l_0 and L' is broken line $A_1A_2A_3A_4A_5A_6A_7$, the function $\alpha(t)$ is sectionally constant on L' and unknown continuous on l_0.

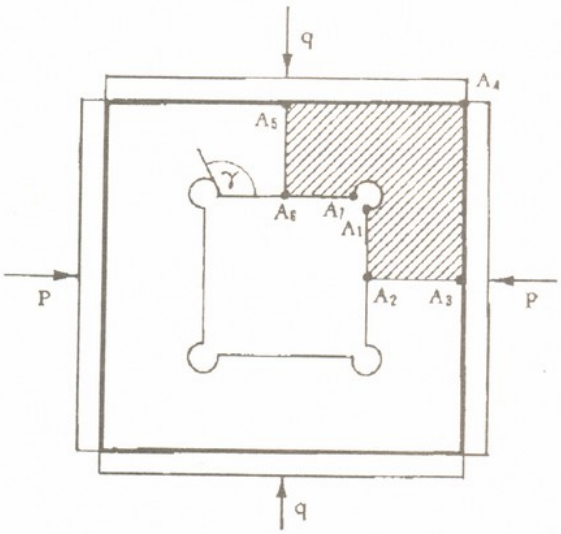

Fig.

The angle γ (Fig.) is obtuse therefore the stresses will be infinite with degree less than $\frac{1}{2}$ at the points A_1 and A_7. Besides the function $\Psi(z)$ is continuously extendable to the boundary except of the point A_4, where the following inequality holds.

$$|\Psi(z)|<\frac{const}{|z-A_4|^{\varepsilon}},\ 0\le\varepsilon<1. \tag{9}$$

In addition equalities (7), (8) consider the equation of contour L' which is

$$\mathrm{Re}(te^{-i\alpha(t)})=\mathrm{Re}(A(t)e^{-i\alpha(t)}),\ t\in L', \tag{10}$$

where $A(t)$ is sectionally constant and has the form

$$A(t)=A_k,\ t\in A_kA_{k+1},\ k=1,2,3,4,5,6.$$

Denote by D_1 the unit semicircle of the complex ζ plane $|\zeta|<1$, $\mathrm{Im}\zeta>0$.

Let the function $z=\omega(\zeta)$ conformally map the region D of z plane onto region D_1 of ζ plane and let a_k be the images of points A_k. Without loss of the generallity we can mean that

$$a_1=1,\ a_4=i,\ a_7=-1.$$

(7), (8), (10) equalities turn into the form

$$e^{2i\alpha_0(\sigma)}\Psi_0(\sigma)=b,\ \sigma\in l. \tag{11}$$

$$\mathrm{Im}\,e^{2i\alpha_0(\sigma)}\Psi_0(\sigma)=0,\ \sigma\in L. \tag{12}$$

$$\mathrm{Re}(e^{-i\alpha_0(\sigma)}\omega(\sigma))=\mathrm{Re}(e^{-i\alpha_0(\sigma)}A_0(\sigma)),\ \sigma\in L, \tag{13}$$

where l and L are images of l_0' and L' respectively; $\Psi_0(\zeta)=\Psi(\omega(\zeta))$, $\alpha_0(\sigma)=\alpha(\omega(\sigma))$, $A_0(\sigma)=A(\omega(\sigma))=A_k$. $\alpha_0(\sigma)$ is known sectionally constant function on L and unknown on l.

In this case for $e^{2i\alpha_0(\sigma)}$ we have [2]

$$e^{2i\alpha_0(\sigma)} = \frac{\omega'(\sigma)}{\overline{\omega'(\omega)}}, \ \sigma \in l \tag{14}$$

By taking into account (14) and differentiating (13) we get

$$\overline{\omega'(\sigma)}\Psi_0(\sigma) = b\omega'(\sigma), \ \sigma \in l. \tag{15}$$

$$\mathrm{Im}\, e^{-i\alpha_0(\sigma)}\sigma\omega'(\sigma)=0, \ \sigma \in L. \tag{16}$$

$$\mathrm{Im}\, e^{2i\alpha_0(\sigma)}\Psi_0(\sigma)=0, \ \sigma \in L. \tag{17}$$

Define the function

$$W(\zeta) = \begin{cases} b\omega'(\zeta), & |\zeta| < 1, \quad Im\zeta > 0 \\ \overline{\omega'(\bar{\zeta})\Psi_0(\bar{\zeta})}, & |\zeta| < 1 \quad Im\zeta < 0 \end{cases} \tag{18}$$

Because (15) we have

$$W^+(\sigma) = W^-(\sigma), \quad \sigma \in l.$$

And consequently the function $W(\zeta)$ is analytic in the unit circle $|\zeta| < 1$.

Using formulae (16), (17), (18) we easily obtain

$$\mathrm{Im}\, e^{-i\alpha_0(\sigma)}\sigma W^+(\sigma) = 0, \ \sigma \in L. \tag{19}$$

Here and bellow L denotes the whole circle line $|\zeta| = 1$.

Rewrite equality (19) as following

$$e^{-i\alpha_0(\sigma)}\sigma W^+(\sigma) = e^{i\alpha_0(\sigma)}\overline{\sigma W^+(\sigma)}, \quad \sigma \in L. \tag{20}$$

Define the function

$$F(\zeta) = \begin{cases} \zeta \overline{W(\zeta)}, & |\zeta| < 1 \\ \frac{1}{\zeta}\overline{W\left(\frac{1}{\bar{\zeta}}\right)}, & |\zeta| > 1 \end{cases}, \tag{21}$$

$F(\zeta)$ is analytic function inside and outside of curve L and by (20) it satisfies the equality

$$F^+(\sigma) = e^{2i\alpha_0(\sigma)}F^-(\sigma), \ \sigma \in L. \tag{22}$$

Thus our problem came to boundary problem of linear relationship unit circle with sectionally constant coefficients [3].

In order that the solution of problem (22) may be the solution of Riemann - Hilbert problem (19) at the same time the following condition must be satisfied

$$\overline{F\left(\frac{1}{\bar{\zeta}}\right)} = F(\zeta). \tag{23}$$

Search the solution $F(\zeta)$ so that

$$F(\zeta) = 0, \quad \text{when } \zeta = 0. \tag{24}$$

For the index of problem (22) we have

$$æ = 5. \tag{25}$$

Taking into account (23), (24), (25) for the solution $F(\zeta)$ of problem (22) we finally get

$$F(\zeta)=\chi(\zeta)(c_1\zeta^4 + c_2\zeta^3 + \overline{c_2}\,\zeta^2 + \overline{c_1}\,\zeta), \tag{26}$$

where $\chi(\zeta)$ is the canonical solution of the same problem and in this case has the following form:

$$\chi(\zeta)=A\prod_{k=1}^{12}(\zeta-a_k)^{\gamma_k}. \tag{27}$$

$$\gamma_1=\gamma_7=0,\ \gamma_2=\gamma_3=\gamma_4=\gamma_5=\gamma_6=\gamma_8=\gamma_9=\gamma_{10}=\gamma_{11}=\gamma_{12}=\frac{1}{2}.$$

By (18), (21), (26) we finally obtain

$$t=\omega(\sigma)=\frac{1}{b}\int_{-1}^{\sigma}\chi(\zeta)(c_1\zeta^3+c_2\zeta^2+\overline{c_2}\zeta+\overline{c_1})d\zeta+c, \tag{28}$$

which is the equation of desired contour.

The unknown constants in (28) can be calculated by taking into account the physical and geometrical conditions of the given problem.

Finding $\omega(\zeta)$ from (18) we determine $\Psi_0'(\zeta)$ and also $\Psi(z)$ which with function $\Phi(z)$ determines the stressed condition of the plate.

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PHYSICS

T.Adeishvili, L.Kopaliani, M.Gogiashvili, G.Tevdoradze

Research of the Process of Gradual Increase and Decrease of the Glow Intensity of the Line $\lambda = 6300$ Å under the Influence of the High-Power Radiowave on the Earth Ionosphere

Presented by Academician J.Lominadze, March 19, 1996

ABSTRACT. **The investigation of processes of decrease and increase of glow intensity of wave length of oxygen atom $\lambda = 6300$ Å wave under the influence of high-power radiowaves on the Earth ionosphere are reported.**

The mechanisms of this radiation are presented, corresponding physical and mathematical models are worked out.

Introduction

Investigation of the artificial glow of the ionosphere is important for diagnostics of effects, occuring in the ionospheric plasma under the influence of electromagnetic waves. At these disturbances data of optical observations can be used for the determination of a number of parameters of the ionosphere and magnetosphere. In the analogous experiments [1,2,3] carried out in the USA transmitters with frequency of 3÷5 MHz were used. Differing from those we interpret results of optical observations of the ionospheric glow under the influence of high-power radio emission of gyrofrequency.

Description of the experiment and its results

The disturbance of the ionosphere was arisen by the powerful pulsed transmitter with verticall radiation of radiowaves on frequency f = 1.35 MHz. Rectangular impulses had a duration of 0.5 Ms and a frequency of running - 50 in second. A detailed description of the radio equipment is given in [4].

As a detector of optical radiation of the ionosphere the modulation photometer with the rotary interference filter was used. Observations were carried out on the wave length λ=6300Å, radiated from the excited level of atomic oxygen $O(^1D_2)$ with energy 1.96 EV. A choice of the line λ=6300Å is conditioned by the low potential of excitation and long time of luminescence ($r \approx 110$ s) of the excited level $O(^1D_2)$. This allowed prolonged accumulation of the registered signal and increased sensitivity of the photometer. Its parameters were: the sensitivity ~5R; the time constant 5÷15 s, the angle of view ~ 6°.

Measurements were carried out in calm geomagnetic conditions in lunarless and cloudless period in the course of three years at the territory of the radiostation. First it was ascertained that the work of the radio transmitter didn't make interference for the photometrical equipment.

Experiments were carried out according to the following plan: the transmitter was periodically switched on for 10÷15 min and it was switched off for the same period of time. Measurements of the intensity of the line λ=6300 Å were carried out continuously both at switched on and off transmitter. The fact of increase of the glow intensity at the disturbance of the ionosphere by the radio-frequency radiation was

ascertained. Dependence of the glow intensity on the local time and the power of the transmitter was investigated. Angular dimensions of the field of increased glow and temporal characteristics of the process were ascertained. Triangulational measurements of the height of the glowing field were carried out.

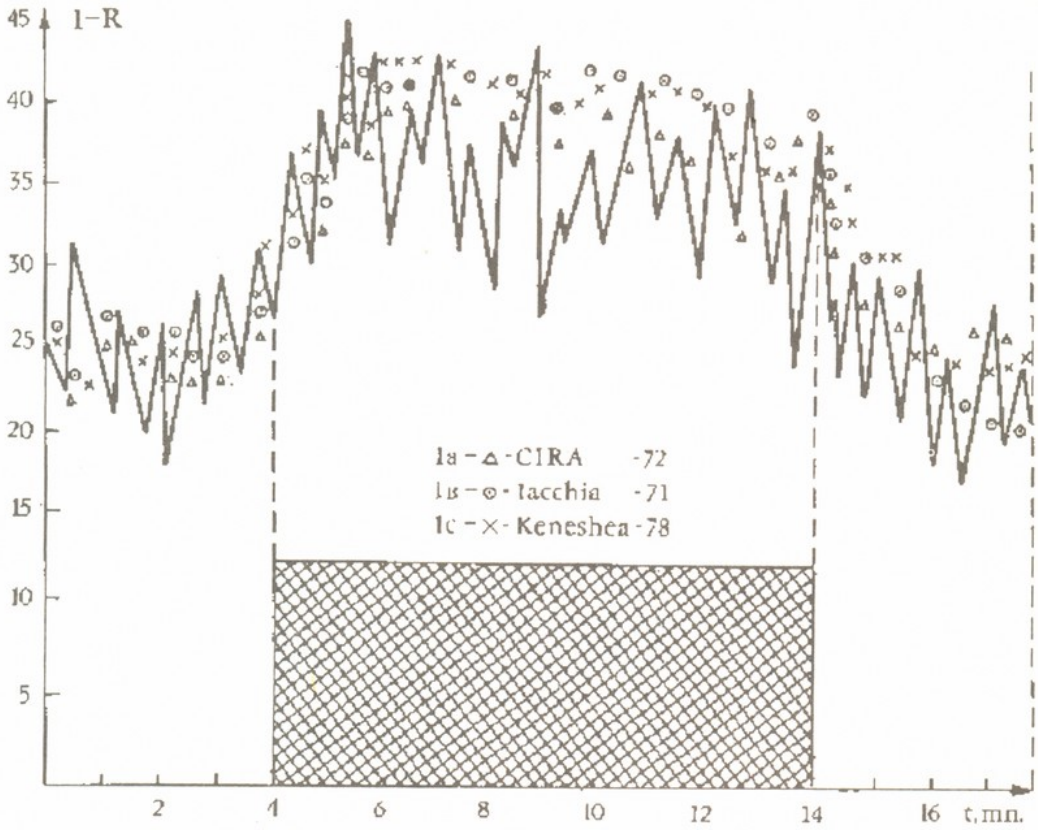

Figure 1.

As a result of numerous observations it was ascertained that under the influence of high-power radio emission on the Earth ionosphere the glow intensity of the red line of atomic oxygen had been increasing on an average 3% that corresponded the absolute increase on 6÷10. Fig. 1 shows changes of the intensity of above background radiation λ=6300Å (sections of the time in which the ionosphere was disturbed by the rifi pulse are shaded). It is shown that in 1.5÷2 min after the beginning of the disturbance the radiation intensity runs into its maximum value. Then in most cases the average value of the intensity hardly changes up to the switch off the transmitter. After the stopping of the disturbance the time of the decrease of the above background glow down up to the background level came also to 1.5÷2 min. But in some cases the glow intensity decreased to the background level still before the switch off the radio transmitter. Analogous effect is described in the paper [3], its rise connected with the action of ionospheric winds. Simultaneously with measurements of the glow with the help of the ionospheric station, determination of the height of the reflection of disturbing wave was carried out. It showed that usually $z \approx 220 \div 270$ km. It must be noted that intensity of the additional glow increases together with the increase of the height of reflection. It is evidently connected with the increase of the height of radiating field and in consequence with the change of the deactivation speed of the excited atoms $O(^1D_2)$.

Angular dimensions of the glowing field of the ionosphere were determined by the scanning of the photometer in different (various) directions. The determination accuracy was rated with the help of the aperture value of the photometer.

Observations from the territory, covered with the transmitting station showed that angular dimensions of the spot in the direction from zenith to the North and South came to 15 and 10°. It must be noted that the aerial of the disturbing transmitter radiates the wave in the cone with the angle between the height and generating line 11÷12°. So the obderved glowing field corresponds the field of the ionosphere disturbed by the radio wave.

The height of the glowing field was determined during the time of base observations carried out from the point in 96 km from the transmitter. The determined height was $200 \div 240$ km, and the height of the disturbing wave reflection $z \approx 250 \pm 20$ km.

Discussion and interpretation of some experimental results

The great part of the received experimental material was discussed and interpreted in works [7,8,9]. Here we try to explain some physical processes occuring at the gradual increase of the glow intensity λ=6300Å during the electromagnetic disturbance and decrease of this radiation after the stopping of the disturbance.

Let's examine the mechanisms of the radiation level $O('D_2)$ the red line of the atomic oxygen.

According [10,11] in our case the generation of the state $O('D_2)$ occurs mainly at the expense of the following processes:

$$O_2^+ + l \xrightarrow{K_1} O('D_2) + O('S_1 3P) \tag{1}$$

$$N(^2D) + O_2 \xrightarrow{K_2} O('D_2^3, P) + NO \tag{2}$$

$$O('S) \xrightarrow{K_3} O('D_2) + h\gamma\,(5577\ \text{Å}) \tag{3}$$

$$O(^3P)\, l \xrightarrow{Q_1} O('D_2, 'S) + l, \tag{4}$$

where K_1, K_2, K_3 are speeds ratios of the processes (1), (2), (3), and Q_1 is a quantity of the section of the impact process (4).

On the heights considered in the experiments the deactivation of the state $O('D_2)$ occurs mainly by the nitrogen and oxygen molecules [10,11].

The time of the existence of the excited states $O('D_2)$, $O('S)$ and $N(^2D)$ is accordingly equal to ≈100 sec., ≈0.94 s, and $\approx 9.3 \cdot 10^4$ s.

Let's suppose that the gradual increase of the intensity of spectral line $\lambda = 6300$Å at the disturbance happens at the expense of the energy accumulation of the excited states $O('D_2)$, $O('S)$, $N(^2D)$ and ions O_2^+ for the time of the existence. The change of the concentration O_2^+, $O('D_2)$, $O('S)$ and $N(^2D)$ at the time of electromagnetic disturbance (front line of the signal) may be described with the help of the following differential equations [12,13,14]:

$$\begin{cases} \dfrac{d[O_2^+]}{dt} = \left\{Q_1[O_2][l]\right\} - \left\{\alpha_1[l] + \alpha_2[l] + \alpha[N_2]\right\}[O_2^+] & (5) \\ \dfrac{d[O('D)]^*}{dt} = \left\{Q_2[O_2^+][l]\right\} - \left\{\alpha_4[N_2] + \alpha_5[O_2] + A_{\lambda_1}\right\}[O('D_2)]^* & (6) \end{cases}$$

$$\frac{d[N(^2D)]}{dt}=\left\{Q_3[N_2][I]+Q_4[NO^+][I]\right\}-\left\{\alpha_6[O]+\alpha_7[O_2]+A_{\lambda_2}\right\}[N(^2D)] \quad (7)$$

$$\frac{d[O('D)]^{**}}{dt}=\left\{Q_5[N(^2D)][O_2]\right\}-\left\{\alpha_4[N_2]+\alpha_5[O_2]+A_{\lambda_1}\right\}[O('D_2)]^* \quad (8)$$

$$\frac{d[O('s)]}{dt}=\left\{Q_6[N_2(A^3\Sigma_u^+)][O(^3P)]+Q_3[O_2(C'\Sigma_u^-)][O(^3P)]\right\}-$$

$$-\left\{\alpha_6[O]+\alpha_7[O_2]+A_{\lambda_3}[O('s)]\right\} \quad (9)$$

$$\frac{d[O('D)]^{***}}{dt}=\left\{Q_8[O(^3P)][O('s)]\right\}-\left\{\alpha_4[N_2]+\alpha_5[O_2]+A_{\lambda_1}\right\}[O('D)]^{***} \quad (10)$$

$$\frac{d[O('D)]^{****}}{dt}=\left\{Q_9[O(^3P)][I]\right\}-\left\{\alpha_4[N_2]+\alpha_5[O_2]+A_{\lambda_1}\right\}[O('D)]^{****}, \quad (11)$$

where Q_1, Q_2, Q_3, Q_4, Q_5, Q_6, Q_7, Q_8, Q_9 are the formation speeds of O_2^+, $O('D)$, $N(^2D)$, $O('s)$ as a result of corresponding reactions; α_1, α_2, α_3 are speeds of loss of O_2^+ by the electrons, nitrogen and molecular nitrogen; α_4 and α_5 – deactivation speeds of the excited state $O('D)$; α_6 and α_7 – speeds of deactivation of the excited state $O('s)$; A_{λ_1}, A_{λ_2} and A_{λ_3} – Einstein coefficients.

While solving equations 5÷11 we consider that the electron concentrations during the radio disturbance is constant and the primary conditions are: when $t=0$, then $O_2^+=0$, $N(^2D)=0$, $O('s)=0$ and $O('D_2)=0$. After putting in corresponding designations the solutions will be:

$$[O('D_2)]^*=C_1[A_1+B_1l^{-\alpha_1 t}-(A_1+B_1)l^{-\beta_1 t}] \quad (12)$$

$$[O('D_2)]^{**}=C_2[A_2+B_2l^{-\alpha_2 t}-(A_2+B_2)l^{-\beta_2 t}] \quad (13)$$

$$[O('D_2)]^{***}=C_3[A_3+B_3l^{-\alpha_3 t}-(A_3+B_3)l^{-\beta_3 t}] \quad (14)$$

$$[O('D_2)]^{****}=A_4(1-l^{\alpha_4 t}), \quad (15)$$

where C_1, A_1, B_1, α_1, β_1, C_2, A_2, β_2, C_3, A_3, α_{21}, B_2, C_3, A_3, B_3, β_3, A_4 and α_4 are designations of corresponding values.

Let's make differential equations of continuity in the case of concentrations change of the component O_2^+, $O('D_2)$, $O('S)$ and $N(^2D)$ for the back front of registered signal.

$$\begin{cases}\dfrac{d[O_2^+]}{dt}=-\left\{\alpha_1[I]+\alpha_2[N]+\alpha_3[N_2]\right\}[O_2^+] & (16)\\ \dfrac{d[O('D_2)]^*}{dt}=\left\{Q_2[O_2^+][I]\right\}-\left\{\alpha_4[N_2]+\alpha_5[O_2]+A_{\lambda_1}\right\}[O('D_2)]^* & (17)\end{cases}$$

$$\begin{cases}\dfrac{d[N(^2D)]}{dt}=-\left\{\alpha_6[O]+\alpha_7[O_2]+A_{\lambda_2}\right\}[N(^2D)] & (18)\\ \dfrac{d[O('D_2)]^{**}}{dt}=\left\{Q_5[N(^2D)][O_2]\right\}-\left\{\alpha_4[N_2]+\alpha_5[O_2]+A_{\lambda_1}\right\}[O('D_2)] & (19)\end{cases}$$

$$\frac{d[O('S)]}{dt} = -\left\{\alpha_6[O] + \alpha_7[O_2] + A_{\lambda_3}\right\}[O('S)] \tag{20}$$

$$\frac{d[O('D_2)]^{***}}{dt} = \left\{Q_8[O(^3P)][O('S)]\right\} - \left\{\alpha_4[N_2] + \alpha_5[O_2] + A_{\lambda_1}\right\}[O('D_2)]^{****} \tag{21}$$

$$\frac{d[O('D_2)]^{****}}{dt} = \left\{Q_9[O(^3P)][I]\right\} - \left\{\alpha_4[N_2] + \alpha_5[O_2] + A_{\lambda_1}\right\}[O('D_2)]^{****} \tag{22}$$

Here designations are the same as in the description of the front line processes. At the solution of equations 16÷22 taking account of front line the primary conditions may be represented as: at $t=0$ $[O_2^+]_I = [O_2^+]_{max}$; $[N(^2D)]_I = [N(^2D)]_{max}$; $[O('S)]_I = [O('S)]_{max}$; $[O('D_2)]_I = [O('D_2)]_{max}$.

If primary conditions of typical parameters of the back front processes coincide with maximum value of these parameters of front line process solutions 16÷22 will be:

$$[O('D_2)]^{*} = 2(a_{21}A_{11}I^{110a_{11}} - a_{21}A_{11}I^{-a_{11}t}) - A_{21}I^{110a_{11}} - A_{22}I^{0,7a_{22}} + A_{33}. \tag{23}$$

$$[O('D_2)]^{**} = 2(a_{43}B_{11}I^{110a_{33}} - a_{43}B_{11}I^{-a_{33}t}) - B_{21}I^{110a_{33}} - B_{22}I^{110a_{33}} + B_{33}. \tag{24}$$

$$[O('D_2)]^{***} = 2(a_{54}D_{11}I^{110a_{55}} - a_{54}D_{11}I^{-a_{55}t}) - D_{21}I^{110a_{55}} - D_{22}I^{110a_{55}} + D_{33}. \tag{25}$$

$$[O('D_2)]^{****} = E_{11}^{110a_{55}} - E_{11}I^{-a_{55}t}, \tag{26}$$

where a_{11}, A_{11}, a_{21}, A_{21}, A_{22}, a_{22}, A_{33}, a_{33}, a_{43}, B_{11}, B_{21}, B_{22}, B_{33}, a_{54}, a_{55}, D_{11}, D_{21}, D_{22}, D_{33}, E_{11} are corresponding designations of typical parameters.

According to /10/ on the examined height the general concentration of the state for front and back lines of registered signal will be:

$$[O('D_2)] = 0,45[O('D_2)]^{****} + 0,4[O('D_2)]^{**} + 0,08[O('D_2)]^{***} + 0,05[O('D_2)]^{*}. \tag{27}$$

Using (12), (13), (14), (15), (23), (24), (25), (26), (27), and standard models of the atmosphere Cira-72, Iacchia-71 and Keneshea-78 we may plot a curve of dependence of concentration changes of the excited state $O('D_2)$ from time as before the beginning as in the process and after radiowave disturbance. These curves are represented in Fig. 1 (1a – according to the model Cira-72, *1b* – according to the model Iacchia-71, 1c – according to the model Keneschea -78). As we can see three atmospheric model curves in the limits of error describe this process very well and are in conformity with experimental record.

Some disagreement between experimental and rated data arises due to the absence in equations of the mechanisms not important for the formation of state $O('D_2)$.

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PHYSICS

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On the Possibility of Static Negative Differential Conductivity Suppression in Order to Observe High -Frequency Radiation in Triple Compounds such as GaAs

Presented by Corr. Member of the Academy T.Sanadze, May 20, 1996.

ABSTRACT. **We investigate current-voltage characteristic (CVC) of hot electrons under intervalley transition in materials such as $Ga_{1-x}Al_xAs$ in strong cross fields $\vec{E} \perp \vec{H}$. For the first time it has been studied the simultaneous influence of magnetic field and smooth change of energy gap (ΔE) between central (low) and upper valleys of conductivity zone both on the quantity of static negative differential conductivity (NDC) and critical field of NDC appearing. It has been illustrated that along with the increasing of magnetic field and decreasing of ΔE the module NDC decreases. As a result of summary action of these effects the maximum on CVC decreases and moves towards large electric fields.**

1. The investigations [1] testify to the fact that under the conditions of intervalley transition (IVT) threefold combinations on the base of GaAs in strong electric and magnetic fields the appearing of dynamic negative differential conductivity in submillimeter spectrum range is possible. Under the same conditions negative static differential conductivity (NDC) which, as a rule, promotes Gunn generations, preventing the observations of a more high frequency oscillations. Proceeding from this, the study of the possibilities of static NDC suppression is of great importance.

It is known that in material of GaAs type the quantity of NDC is decreasing with increasing of magnetic field. At this time the maximum on current-voltage characteristic (CVC) is moving towards high electric fields. These results are well grounded by numeric experiments using Monte-Karlo method [2].

The investigation deals with GaAs material exclusively, in which the energetic gap $\Delta\varepsilon$ between central (lower) and accessory (upper) valleys of conductivity zones more than in one order exceed the energy of intervalley phonon ($\hbar\omega^*$). In GaAs $\Delta\varepsilon = 16\hbar\omega^*$, $\hbar\omega^* = 0{,}8\ \hbar\omega_0$, ω_0 is polar optic phonon frequency.

The investigation of above mentioned peculiarities in those materials where the structure of conductivity zones can be smoothly and arbitrarily changed from GaAs structure (i.e. when $\Delta\varepsilon >> \hbar\omega^*$) up to that structure of the material, under which $\Delta\varepsilon$ becomes $\hbar\omega^*$ order. As it is known to us, such kind of investigations have not yet been performed. The interest towards this problem is still conditioned by the fact that under small $\Delta\varepsilon$ in conditions of dynamic (ballistic) intervalley transferring (IVT) in the momentum space of lower (Γ) valley the group motion of electrons take place (all the electrons have almost the same transit time). This can lead to the dynamic NDC on the frequencies of transit resonance, moreover that this frequency can appear in submillimeter spectrum range [3]. The present paper reports the research data of CVC under the conditions of dynamic IVT in strong $\vec{E} \perp \vec{H}$ fields in materials like

$Ga_{1-x}Al_xAs$. For the first time simultaneous influence of magnetic field and smooth change of $\Delta\varepsilon$ both on the quantity of static NDC and on the critical field of its appearance has been investigated. These investigations have been basically done for short samples when the Hall field is not forming. The effects connected with peculiarity of IVT kinetics in strong fields ought to reveal themselves more with the decreasing of temperature. That's why all the calculations done in this paper are attributed to cryogenic temperatures.

2. The study is carried out by solving Boltzmann's kinetic equation. Let's suppose that crystal temperature T satisfies the condition $k_0T<<\hbar\omega^*$ (k_0 is Boltzmann constant). In this case intervalley transition goes with only spontaneous radiation of Intervalley phonon. Let's regard such electric fields in which the heating time of electrons (τ_E) in Γ-valley up to the energy of the beginning intervalley transition – $\varepsilon_0 = \Delta\varepsilon + \hbar\omega^*$ is less than characteristic time of electrons scattering on phonons inside Γ-valley. In such field the regime of dynamic IVT is set. On the other hand it is known that if $E < 25$ kV/cm, the distribution function of electrons in upper valleys f_x has the appearance of Maxwel-Boltzmann distribution [4]. As the fields we have observed are less than pointed quantity we'll consider function f_x equilibrium. The directions of fields in which the studies have been carried out are as following: $e\vec{E}\uparrow\uparrow\vec{z}$ $\vec{H}\uparrow\uparrow\vec{x}$ (e is electron charge).

By switching cross magnetic field ($\vec{E}\perp\vec{H}$) the phase electron trajectories in momentum space of Γ-valley are curving. If the fields are such ones that they fulfill the conditions:

$$P_C = \frac{C_0 m_\Gamma^* E}{H} > \frac{P_0 + P_1}{2} \equiv P_c^*, \qquad (1)$$

then all phase trajectories are open (that is all electrons moving in this trajectories get to the energy ε_0). Here we give the marks: $P_0 = \sqrt{2m_\Gamma^*\varepsilon_0}$, $P_1 = \sqrt{2m_\Gamma^*(\Delta\varepsilon - \hbar\omega^*)}$, C_0 is light speed in vacuum, m_Γ^* is electron effective mass in Γ-valley. From the condition (1) comes that for every fixed H there exist such meaning of electric field E^* that under the fulfillment of condition $E > E^*$ all the trajectories of electrons are open:

$$E^* = \frac{P_0 + P_1}{2C_0 m_\Gamma^*} \cdot H. \qquad (2)$$

In case reverse to the condition (1) a part of phase trajectories are locked up in a circle and thus the electrons moving in these trajectories are found in magnetic "trap" (e.i. they don't reach ε_0 energy). For these electrons it is necessary to take into account intravalley scattering on phonons with characteristic frequency ν_{op}. Transition of these electrons to the open trajectories is the result of finite quantity ν_{op}.

3. Current voltage characteristic was being built by general integral expression for the current with using the function having been found by solving kinetic equation written both for the open and locked trajectories. Because of the complexity of this integral it was solved numeric by Monte-Karlo method. Figures 1 and 2 show a part of these results on the study of CVC. The given curves indicate the following regularities: along with the increasing of magnetic field the module NDC is decreasing; with increasing of H the maximum on CVC is moving towards high electric fields; under the same meanings of fields the less $\Delta\varepsilon$ the less module NDC is; the decreasing of

frequency scattering inside Γ-valley decreases electron conductivity moving in open trajectories. Each of the enumerated results is explained qualitatively well by taking into account all the basic processes, characterizing kinetics of IVT in the examined conditions. Actually, the decreasing of NDC module along with decreasing of $\Delta\varepsilon$ is primarily connected with the decreasing of maximum on CVC which might be effected by the decreasing energy ranges $0 < \varepsilon < \Delta\varepsilon - \hbar\omega^*$ in which the distribution function appears to be inverted. The NDC being connected with such inversion is especially sensible to the change of H for small meanings of $\Delta\varepsilon$ when the increasing of H roughly worsens the inversion condition.

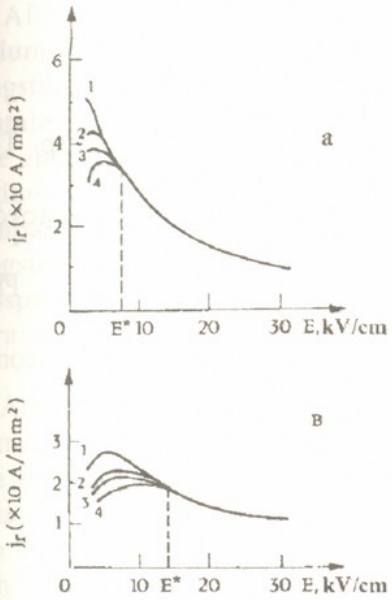

Fig.1. Current-Voltage characteristic in the Γ-valley for
$\Delta\varepsilon = 4{,}5\ \hbar\ \omega^*$ ($Ga_{0,7}Al_{0,3}As$).
(a) - $H = 10$ kOe, $\omega_c = 1{,}9\cdot10^{12}$ sec^{-1} ($E^* = 7{,}5$ kV/cm);
(b) - $H = 20$ kOe, $\omega_c = 3{,}8\cdot10^{12}$ sec^{-1} ($E^* = 15$ kV/cm);
ν_{op}: 1-1,2·10^{12} sec^{-1}, 2 - 6·10^{11} sec^{-1}, 3 - 4·10^{11} sec^{-1}, 4 - 2·10^{11} sec^{-1}

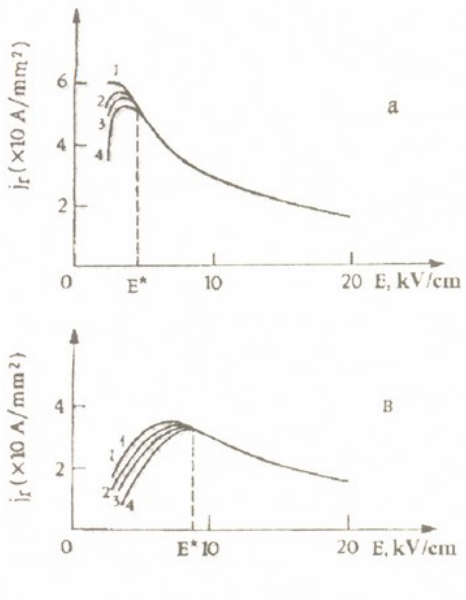

Fig.2. Current-Voltage characteristic in the Γ-valley for
$\Delta\varepsilon = 1{,}7\ \hbar\ \omega^*$ ($Ga_{0,63}Al_{0,37}As$).
(a) - $H = 10$ kOe, $\omega_c = 1{,}8\cdot10^{12}$ sec^{-1} ($E^* = 4{,}5$ kV/cm);
(b) - $H = 20$ kOe, $\omega_c = 3{,}6\cdot10^{12}$ sec^{-1} ($E^* = 9$ kV/cm);
ν_{op}: 1-1,2·10^{12} sec^{-1}, 2 - 6·10^{11} sec^{-1}, 3 - 4·10^{11} sec^{-1}, 4 - 2·10^{11} sec^{-1}

Thus for such $\Delta\varepsilon$ the decreasing of static NDC module is easily obtained. For example, for $\Delta\varepsilon = 4\text{-}5\hbar\omega^*$ under $H = 40$ kOe the NDC quantity oughtn't to be sufficient for the instability to appear in constant electric field.

Under fixed E the growing of H causes the increasing of electrons hold-up time in Γ-valley. Part of these electrons are delayed in magnetic trap and therefore the current is decreasing. Under fixed H the increasing of E causes electrons transferring from closed trajectories to the open ones and their share in conductivity is increasing. After the switching of strong IVT the current is fallen down again because of the well known reason.

The movement of maximum towards the large E under the increasing of H is explained by this. The quantity dependence of current voltage characteristic from

electrons scattering frequency inside Γ-valley given above bears a pure model character. It points to the role of such scattering in the range of electric fields $E < E^*$. It is evident that for $E < E^*$ the CVC must exactly coinside with the CVC which is built for the case of complete absence of scattering on the open trajectories. That's why the curves built for different ν_{op} have been merged in one curve under $E = E^*$.

The results of detailed investigations and analytical reasoning show (we don't use the curves here) that under $\Delta\varepsilon \approx \hbar\,\omega^*$ the module of static NDC becomes positive. This circumstance is also confirmed by the calculations of frequency dependence of NDC - $\sigma(\omega)$ in high-frequency field recently carried out in [1].

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ეროვნული ბიბლიოთეკა

PHYSICS

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Study of High-Temperature Thermo-Emissive Converter Characteristics Dependence on Collector's Material

Presented May 30, 1996

ABSTRACT. **This paper presents the experimental results of the cylindrical cesium-plasma thermo-emissive converter (TEC) heat-power characteristics. The tungsten layer served as an emitter with preferable orientation (110)."Oxygen-containing" niobium or polycrystalline tungsten performed collector functions. The emitter and collector temperatures during TEC functioning in a converting regime were T_E = 2000-2200 K and T_C = 1000-1300 K correspondingly. In comparison with the "oxygen-containing" niobium the use of the polycrystalline tungsten plated layer as collector in the TEC with tungsten emitter is more prospective because of simplification of device producing technology. Converter parameters and resource remain immutable on high level.**

Among powerful autonomous current sources for long-term space devices the thermo-emissive nuclear power plant is considered as the most prospective one [1,2]. The main element of this plant is the cesium - plasma high-temperature thermo-emissive converter (TEC) in which the heat produced by nuclear fuel is transformed into the direct electric current of low voltage and high density. The efficiency of the high - temperature thermo - emissive power plant approximates the theoretically possible value [2] and to a large extent depends on a TEC material since the problem concerning the emitter is solved with utilization of polyfacets tungsten monocrystalline materials coated by means of gas-phase method [3]. For calculating such plants parameters and forecasting their initial electric characteristics it is necessary to study characteristics of cesium-plasma model of thermo-emissive converters within high temperatures range and to work out tables for collector various materials. Such data nowadays are not available.

In this work results of the cylindrical cesium-plasma TEC characteristics experimental study carried out on two TEC models at emitter and collector temperatures T_E = 2000-2200 K and T_C = 1000-1300 K are presented.

An "oxygen-containing" niobium served as a collector in the first TEC, and in the second one collector was made of polycrystalline tungsten film with a thickness of 30 mcm plated upon the niobium-zirconium alloy. In both models the role of emitter was performed by tungsten film with thickness of 200 mcm and (110) – preferable orientation plated upon the [111] – direction molybdenum monocrystal by means of the method of chemical transfer in chloride area. The gap between electrodes was 0.25 mm. Experiments were carried out on the standard test bench [4] which gave possibility to achieve $1,10^{-4}$ Pa of static vacuum by means of electrodes degassing with non-oil pumps.

The temperature - kinetic regimes of devices electrodes, working volumes and other units, as well as their electric characteristics were obtained, registered and processed by methods analogous to those described in [1,4].

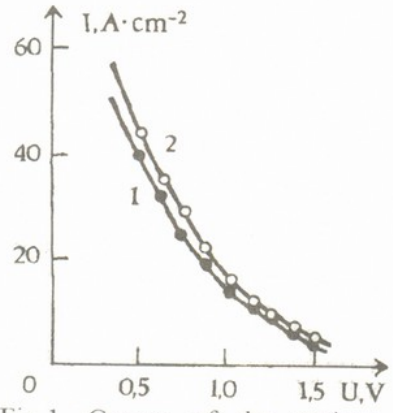

Fig.1. Curves of the cesium-plasma TEC volt-amperic characteristics under Te=2200 K: 1 - "Oxygencontaining" niobium collector, Tc = 1200 K. 2 - Polycrystalline tungsten collector, T_C = 1100 K.

The curves of typical volt-amperic characteristics of thermo-emissive converters for an emiter's temperature 2200 K are shown in Fig.1. As it is evident from the figure the volt-amperic characteristics of the second device are at an average 10 % better than characteristics of the TEC with "oxygen-containing" niobium collector. At the same time it was found that in the first device the cesium vapours optimum pressure at the aforementioned temperature conditions was 1500 Pa and in the second device - 810 Pa. This difference between pressures indicates that plasma losses in the second device are small.

The study of dependence of cesium-plasma TEC characteristics on the collector's temperature show that under emitter's fixed temperature conditions collector's optimum working temperature value is about 1200 K for the "oxygen-containing" niobium, and approximately 1100 K for the polycrystalline tungsten. The optimum value of the working temperature of the "oxygen-containing" niobium collector depends on the quantitative relationship between niobium, tungsten, cesium oxides in the complex layer formed upon the collector's working surface, and on the presence of oxygen free atoms [1,5]. The relationship between concentrations of components of the complex layer actually existing on the surface of such a collector, chemical bonds and surface structure determine the "oxygen-containing" niobium collector properties [6].

It needs to mention that the oxygen-containing collector made by any technology serves at high temperature as a free oxygen source in the working volume of the cesium-plasma TEC. This free oxygen provokes oxidation-reduction reactions and the so-called "water cycle" [7] is being established which transfers an emitter's material (tungsten in our case) to the collector surface. This process promotes considerable decrease of emitter and on the whole cesium - plasma TEC resource.

Besides, the detailed analysis performed in [8] has shown the cesium-plasma TEC efficiency substantially depends on the temperature of the collector.

At the relatively low collector temperature ($T_C < 1000$ K) the presence of oxygen in the cesium TEC working volume provokes the significant increase of the specific power of the device. The first reason of this is an amelioration of emitter's adsorption properties which permits to achieve large emission at cesium relatively low pressure and to reduce considerably plasma losses. The second reason is the decrease of collector's output work and increase of voltage.

At collector's high temperature ($T_C > 1200$ K) when the reverse emission current is significantly increased the low output work of collector does not cause any more the useful voltage growth. Efficiency of the cesium-oxygen TEC becomes less than efficiency of the cesium converter. It occurs because of the plasma electrons temperature increase caused by free oxygen presence within the device's working volume , and due to reducing of the plasma voltage [8]. The physical essence of this phenomenon is bound with the existence of generated in the "water cycle" process tungsten "flying" oxides in low temperature plasma [7]. These oxides and oxygen engender negative ions in plasma. These ions provoke a partial relaxation of an excited

state of cesium atoms and this worsens the gradual ionization process of cesium atoms and also makes worse conditions for neutralization of electrons' volume charge.

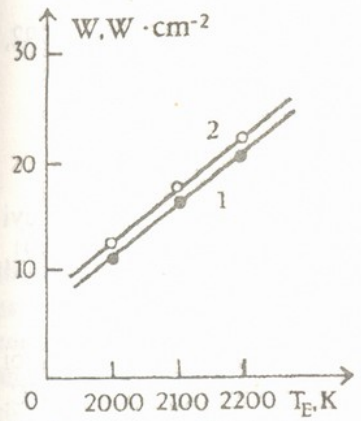

Fig.2. $W_{max} = f(T_E)$ dependence under Tc=1200 K for various collectors: 1 - "Oxygencontaining" niobium collector; 2 - Polycrystalline tungsten collector.

Dependence of a maximum electric power generated by the cesium-plasma TEC on the emitter's temperature is shown in Fig.2. As it is evident from the figure for both collectors the maximum electric power generated by TEC increases almost linearly with the growth of emitter temperature. In case of equal temperatures power generated by TEC with polycrystalline tungsten collector is in average 10 % bigger than power produced by TEC with "oxygen-containing" niobium collector. Beside this, electric parameters of the cesium-plasma TEC with the plated polycrystalline tungsten collector coincide in precision with results achieved in [4] for an analogous device in which collector's functions were performed by the polycrystalline tungsten layer plated by gas-phase method. Measurements were carried out at emitter's relatively low temperatures (T_E=2000-2100 K) and only one collector's temperature was (T_C=1000 K). It indicates that the produced by any technology collector's polycrystalline tungsten layer coupled with tungsten (110) monocrystalline emitter determines high values of power generated by high-temperature cesium-plasma TEC. However the proof of this statement requires studying volt-amperic characteristics of the other different technologies cesium-plasma TEC with tungsten collector within wide ranges of electrodes working temperatures.

Analysis of experimental results lead us to following conclusions:

1. The use of the "oxygen-containing" or oxidized niobium as a collector of the high-temperature cesium-plasma TEC with tungsten emitter is not advisable because the generated electric power is less than that of the thermo-emissive converter with a polycrystalline tungsten collector.

2. The use of the plated polycrystalline tungsten layer as a collector of the cesium-plasma TEC with tungsten emitter is promising because the technology for collector becomes easier and TEC electric parameters, resource and reliability are of high values.

3. On the base of experimentally received volt-amperic characteristics the tables of electric parameters (electrodes temperature, cesium pressure and generated current density dependence on the voltage between electrodes) of the cesium-plasma TECs with "oxygen-containing" niobium and polycrystalline tungsten collectors are created. These tables are indispensable for researchers to calculate parameters of high-temperature thermo-emissive nuclear power plants and to forecast initial electric characteristics.

The Institute is ready to give the above mentioned tables to any interested organisations and researchers on the collaboration basis.

Sukhumi Institute of Physics and Technology

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GEOPHYSICS

Academician B.Balavadze, L.Latynina, R.Karmaleeva, V.Abashidze

Results on Harmonic Analysis of Tidal Deformations for Inguri Region

Presented June 17, 1996

ABSTRACT. **Harmonic analysis of tidal deformations has been carried out on the basis of data obtained in Inguri region. Length of the material comparatively exceeds length of series used in the previous works. The analysis confirmed conclusion inferred earlier that the massif on which the dam lies, is not weakened and easily deformable zone. It appears that the massif experiences general contraction. The same was noted by means of geodetic measurements of distances.**

The main problem for deformographic stations in Inguri region is the study of modern movements of the earth surface, caused by abyssal tectonic processes and human engineering activity. Harmonic analysis of the lunar and solar tidal deformations provides with some information about the elastic properties and the tension state of the earth crust in the investigated region. In papers [1] and [2] the preliminary results on the harmonic analysis of tidal deformations in Inguri region were given. The main goal of the present paper is to obtain additional data of anomaly of tidal deformations and temporal stability of the tide. In connection with filling up of the reservoir and changing of the hydrogeological condition in the area close to the dam, the mechanical properties of rocks undergo the changes and this fact might be reflected on parameters of tidal waves. With this assumption in mind we processed the materials of deformographic observations covering the periods prior and after filling up of the reservoir.

Harmonic analysis is accomplished by B.Pertsev's method with the sliding step of twenty four hours in each 29 day series [3]. The greater part of data related to the concrete central day is obtained as the average data of seven successive sliding series. This permits to avoid periodicities, occurring during the data processing (filtration). Below, in Tables 1 and 2 we give the estimation of the amplitudes and steps of the phases of five main tidal waves for the periods of 1975-1977 and 1979-1984 correspondingly, i.e. for the periods prior and after the filling up of the reservoir.

The comparison of the average estimates of amplitudes of the observed tidal waves with the theoretically calculated estimates (Table 1) shows that the amplitudes of all main waves are 1.5 - 2 times smaller than the theoretical estimates. We obtained the same result earlier analyzing the data of the observations for 1974 [1]. It was concluded also that massif on which the dam lies is not the weakened and easily deformable zone. It appears that the massif experiences general contraction. Now it follows, that processing longer series of observation confirmed the above mentioned result, obtained on relatively small amount of material.

In connection with the above-mentioned it would be useful to quote results of the geodetic measurements in the dam region starting from 1976. Geodetic Enterprise of Georgia (nowadays the Department) carried out the second class levelling along the line Jvari - Khaishi and linear - angular range - finding measurements in geodetic quadrangles and cross sections throughout the dam region [4]. We analyzed the results of repeated measurements (carried out five times) of the lengths of sides of quadrangle

in the dam region carried out in 1978-1985. The analysis of repeated measurements both along the dam and along the Inguri gorge shows the decrease of the lengths of the sides of quadrangle, hence the large scale geodetic measurements also show reproachement of the observation posts i.e. approve our assumption about the consolidation of the whole massif.

Table 1

Amplitudes and phases of tidal waves prior to the filling up of the reservoir (estimates for 1974 are from [1])

Centr. day	Defor-mograph.	No. of series	Amplitudes $\times 10^{-9}$					Shifts of phases $\Delta\varphi°$				
			M_2	S_2	N_2	K_1	O_1	M_2	S_2	N_2	K_1	O_1
1975												
02.02	D_1	3	5.63	2.62	1.46	1.91	1.48	14	0	13	12	7
16.05	"	4	5.90	226	0.71	1.07	1.53	21	15	115	-46	10
03.11	"	7	7.20	3.73	2.01	2.29	2.36	2	7	40	-17	-19
27.11	"	7	7.28	3.49	1.57	2.15	2.33	2	8	0	1	-19
1977												
30.05	D_2	7	6.56	2.57	2.28	0.47	1.43	15	0	31	-33	-30
16.07	"	1	6.98	2.03	2.23	1.00	0.95	13	5	9	-37	2
28.07	D_1	7	6.73	3.45	1.25	1.88	0.47	11	11	-39	-47	96
11.09	"	7	5.20	2.14	0.97	2.95	0.96	17	-7	-76	-104	-36
12.10	"	7	6.29	2.74	3.28	2.78	1.61	-15	13	-1	-37	-175
17.11	"	7	5.56	5.00	3.46	1.78	2.53	16	-9	-65	-50	5
28.11	D_2	7	7.11	3.87	2.22	2.01	3.33	51	42	115	17	96
13.12	D_1	7	5.34	3.96	1.54	1.88	2.53	-4	2	-6	9	7
16.12	D_2	1	6.19	4.92	1.52	2.31	3.29	-9	1	-15	17	5
Aver. for 1974-1977			6.77 ±0.21	3.59 ±0.16	1.79 ±0.13	2,03 ±0.14	2.18 ±0.14	10 ±5	7 ±4	9 ±16	-24 ±16	-4 ±18
Theor. est.			11,80	5,50	2,30	7,20	5,10					

Further it seems important to compare the parameters of tidal waves for time intervals prior and after the filling up of the reservoir, given in Tables 1 and 2. The analysis of the material shows the changes in amplitudes of tidal waves. First of all let's consider twelve hours wave M_2 as the most exactly definable wave: it is the largest one observed at the observation point and its period (12 hours 25 min) considerably differs from twelve hours and twenty four hours periods.

Average estimate of the amplitude M_2 according to the 13 independent series in 1974 was $(7.20 \pm 0.40)\times10^{-9}$ and in the period from 1974 to 1977 according to the 26 independent series was $(6.77 \pm 0.21)\times10^{-9}$ (Table 1). After filling up of the reservoir in the period from 1979 to 1984 according to 9 independent series average estimates of the amplitude M_2 equal to $(8.03 \pm 0.60)\times10^{-9}$ (Table 2). This variation of the amplitude just slightly differs from the mean quadratic error of the average estimate. In spite of this we think that after filling up of the reservoir it shows some increase of the amplitude M_2.

Considerable changes undergo the amplitudes of the waves S_2 and K_1. The amplitude of S_2 wave has grown 1.6 times and the amplitude of the wave K_1 - 3.5

times. The amplitude of the wave O_1 doesn't change considerably. It can be seen that the amplitudes which have undergone changes are the ones of those waves (S_2, K_1) that have periods close to 24 and 12 hours. It seems that those changes happened due to the appearance of the intensive twenty four hour temperature wave. The thing is that the filling up of the reservoir led to the change of the level of subterranean waters and the bed–rock saturation with water. As a result the surface stratum experienced big thermal deformation and the circulation of the subterranean waters received twenty four hour periodicity. In order to verify this conclusion one has to divide the group of waves K_1 and single out the wave S_2. At the same time in order to compare one has to carry out harmonic analysis by Venedikov method.

Table 2

Amplitudes and phases of tidal waves after the filling up of the reservoir

Centr. day	Deformo-graph	No. of series	Amplitudes $\times 10^{-9}$					Shifts of phases $\Delta\varphi°$				
			M_2	S_2	N_2	K_1	O_1	M_2	S_2	N_2	K_1	O_1
1979												
10.03	D_2	1	7.84	3.74	1.39	6.42	0.77	7	3	20	-32	46
25.09	"	7	7.59	7.71	2.45	11.94	3.47	32	43	2	158	57
1980												
20.12	D_1	7	5.15	4.87	1.51	7.78	1.60	64	38	224	-3	134
1981												
06.01	D_1	7	5.82	4.06	1.35	7.21	0.73	45	20	176	-47	180
1982												
11.10	D_2	7	9.96	6.71	2.21	11.39	2.52	6	18	30	77	-43
09.11	"	7	10.60	5.53	1.79	5.99	1.90	9	23	33	49	3
08.12	"	7	9.33	7.57	2.49	4.48	2.28	5	13	-24	19	-10
1984												
06.02	D_2	7	8.37	5.33	1.79	6.51	2.36	-2	9	3	6	23
28.09	"	7	7.64	6.59	2.90	5.67	1.83	-28	-6	-80	-114	-34
Aver. for 1974-1984			8.03 ±0.60	5.79 ±0.48	2.01 ±0.18	7.49 ±0.85	1.94 ±0.29	15 ±9	18 ±5	60 ±28	12.5 ±26	39.5 ±25

Thus from the obtained results it could be concluded that the growth of the wave M_2 after the filling up of the reservoir indicates the weakening of solidity of the rock while the grow of S_2 and K_1 indicates appearance of big twenty four hour temperature waves, showing active circulation of the subterranean waters or the growth of the heat conductance of the rock.

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ORGANIC CHEMISTRY

J.Kereselidze, N.Raevski

Quantum-Chemical Study of Conformation of Phenylhydrazone Ethylpyruvate

Presented by Corr. Memb. of the Academy D.Ugrekhelidze, May 23, 1996

ABSTRACT. **In the MNDO AM1 quantum - chemical method the enthalpy (ΔH) for conformers of phenylhydrazone ethylpyruvate were calculated. It was shown that initial state Fischer's indolization of phenylhydrazone ethylpyruvate has anti - S - trans - cis - trans conformation.**

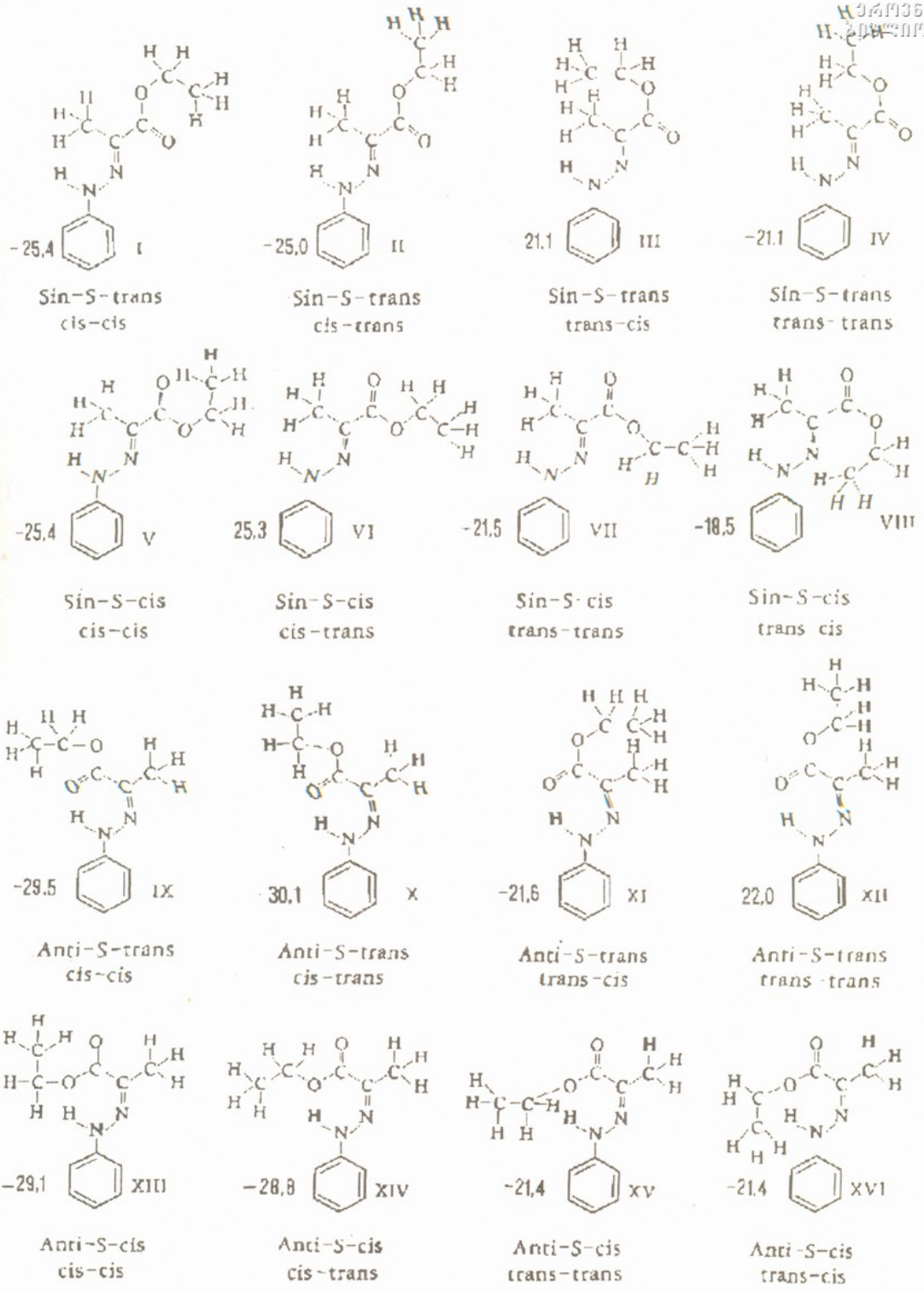
The modern approach to the investigation of mechanism of complex chemical reactions considers preliminary study of conformation of initial compounds. The conformation of phenylhydrazone of Ethylpyruvate as the initial compound in Fischer's indolization was studied. By MNDO AM1 quantum - chemical method [1] the enthalpy $\left(\Delta H, \frac{kcal}{mole}\right)$ for 16 conformers phenylhydrazone (I - XVI) were calculated. These data are given on structural diagram. The isomer in which aniline is arranged in cis-position to *C=N* bond, is considered as sin-isomer (I - VIII) and in trans - position - as anti-isomer (IX - XVI) [2]. Besides for each of them 8 conformation structures

(N =) C - C (= O), (O =) C - O (- CH_2CH_3) and (O = C -) O - C (- H_2CH_3)

can exist in respect to bonds. For example in sin - S - trans-cis - cis conformere (I) carbonyl and methyl groups in respect to (N =) C - C (= O) bond are arranged in trans-position carbonyl and ethyl groups in respect to (O =) C - O (- CH_2CH_3) bond in cis - position and carbonyl and methyl groups in respect to (O - C -) O - C (- H_2CH_3) bond also in cis - position.

As we can see from structural diagrams the most stable are (IX) and (X) conformeres, for which enthalpies are equal ΔH = 29.5 and 30.1 $\frac{kcal}{mole}$ correspondingly. This can be explained by stabilized intramolecular hydrogen bond (IHB) and minimal steric difficulties . IHB can be formed in (XI) and (XII) conformers but steric difficulties are more significant here.

So we can conclude that in initial state of Fischer's indolization of phenylhydrazone of ethylpyruvate has anti - S - trans - cis - trans conformation.



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ORGANIC CHEMISTRY

M.Gverdtsiteli, R.Chikvinidze, I.Gverdtsiteli

Algebraic Investigation of Radical Elimination Reactions

Presented by Corr. Member of the Academy L.Khananashvili, February 4, 1996

ABSTRACT. **Correlation between the energies of perturbations for the radical elimination reactions and the determinants of ANB - matrices for chloralkanes, components of these processes, was investigated.**

The method of perturbation is efficiently used in most quantitative theories of chemical reactions [1]. Analytic formulae are derivated for concrete types of chemical reactions. For the process of radical elimination

$$RCl + Na \longrightarrow R\cdot + NaCl \qquad (1)$$

the energy of perturbation is equal:

$$\Delta E = \sum_{k}^{o} \frac{c_{rj}^2 c_{sk}^2 \beta_{rs}^2}{\alpha_j - \alpha_k} - \sum_{k}^{u} \frac{c_{rj}^2 c_{sk}^2 \beta_{rs}^2}{\alpha_j - \alpha_k}, \qquad (2)$$

where "o" means occupied and "u" - unoccupied molecular orbitals; c_{rj} and c_{sk} are coefficients attached to atomic orbitals; β_{rs} is resonance integral; α_j and α_k are coulomb integrals. In Table 1 the energies of perturbations of (1) process for several R [2] are illustrated.

Table 1

Δ_{ANB} and ΔE for radical elimination reactions

R	ΔE(ev)	Δ_{ANB}
CH_3	1.379	50
C_2H_5	1.404	84
i - C_3H_7	1.494	654
i - C_4H_9	1.496	2460

This process was investigated in terms of ANB - matrix method. The diagonal elements of ANB - matrix represent atomic number of chemical elements, nondiagonal ones - the multiplicity of chemical bonds [3,4]. For arbitrary XYV molecule ANB - matrix has a form:

$$XYV \quad \begin{Vmatrix} Z_x & \Delta_{xy} & \Delta_{xv} \\ \Delta_{xy} & Z_y & \Delta_{yv} \\ \Delta_{xv} & \Delta_{yv} & Z_v \end{Vmatrix}, \qquad (3)$$

where Z_x, Z_y and Z_v are atomic numbers of X, Y and V chemical elements; Δ_{xy}, Δ_{xv} and Δ_{yv} represent multiplicities of chemical bonds between X and Y, X and V, Y and V. The values of determinants of ANB - matrices (Δ_{ANB}) for several R are listed in Table 1.

$\Delta E \sim \lg(\Delta_{ANB})$ equation was constructed on computer and it has a form:

$$\Delta E = 0.074 \lg(\Delta_{ANB}) + 1.262 \qquad (4)$$

The correlation coefficient r is equal to r =0.998, so, correlation is good. Thus we can consider $lg(\Delta_{ANB})$ as the topologic index [5] for process (I).

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ORGANIC CHEMISTRY

E.Usharauli, L.Kortava, I.Edilashvili

Mass-Spectral Studies of Aromatic Fragments of Tar-Asphaltene Compounds of Oil

Presented by Academician T.Andronikashvili, April 8, 1996

ABSTRACT. **Hydropyrolizates of tar-asphaltene compounds of Norio, Supsa and Samgori oils obtained by the authors' method previously studied due to mass-spectral analysis. As a result aromatic fragments of molecules of the compounds were determined.**

Phenanthrene, pyrene and chrysene structures were identified together with the trace amounts of more high-condensed aromatic structures.

Modern oil processing approaches have almost exhausted potential of hydrocarbon components of oils. Tar-asphaltene components remain as the most essential sources for further improvement of use rate of oils for conducting more profound treatment and obtaining their additional hydrocarbonaceous products. For more efficient application of heavy petroleum residues it is necessary to know their composition, structure and characteristics.

The composition and characteristics of tar-asphaltene compounds have already been studied rather profoundly. The structure of their molecules has been investigated rather scantily. An idea according to which polycyclic condensed systems, namely aromatic ones, are the principal structural blocks of these molecules was generally adopted [1].

The present paper deals with the exposure and study of the afore-stated chemically most active aromatic structures and hence the most interesting components of oils.

A method of hydropyrolitic fragmentation of hydrocarbons developed by the authors has been used to study aromatic fragments of tar-asphaltene compounds [2]. The applicability of the method with respect to the petroleum hydrocarbons was verified by the study of aromatic fragments stability of individual hydrocarbons of the known structures in the conditions of hydropyrolysis [3].

The study of the aromatic fragments of tar-asphaltene compounds of oils was conducted on Georgian oils of Norio, Supsa and Samgori origin significantly differing in their chemical nature, not with standing the fact that all of them belong to the lowsulphurous oils.

Asphaltenes of the studied oils were isolated through precipitation of their solutions in petroleum ether of b. p. 70°C. Oil: Petroleum ether ratio was 1:39 respectively. Resinous compounds were isolated from the remaining solution by means of adsorbtion in columns over silica gel ASK. Both fractions of tarry compounds from upper two black and brown colour silica gel zones were extracted in Soxlett apparatus by means of benzole.

Autoclave hydropyrolysis of tars and asphaltenes were carried out at 450°C, initial hydrogen pressure - 7 MPa, process duration - 4 hr.

The compounds extracted from hydropyrolysates by dioxane were studied by gas-liquid chromatography [4] and mass-spectrometry. It should be noted here that mass-

spectrometric method appeared to be more efficient giving more precise information on the molecular structure of the principal components hydropyrolysates.

Table

Distribution of polycyclic aromatic hydrocarbons identified in hydropyrolysates according to their molecular masses; mass %.

hydrocarbons	Molecular mass	Hydropyrolysates					
		tars	asphaltenes	tars	asphaltenes	tars	asphaltenes
		Norio oil		Supsa oil		Samgori oil	
1	2	3	4	5	6	7	8
Phenanthrene	178	34	33	39	46	43	47
and alkyl	192	22	22	23	23	26	27
deri-	206	18	18	16	14	17	17
vatives	220	13	14	12	9	9	9
	234	8	9	7	5	5	—
	248	5	4	4	3	—	—
Pyrene and	202	23	22	31		42	28
alkyl deri-	216	20	10	26		20	25
vatives	230	18	19	19		13	18
	244	15	16	13		10	13
	258	13	13	7		8	9
	272	7	2	4		5	5
	286	4	4	—		2	2
Chrysene	228	40	40	33	39	60	38
and alkyl	242	18	20	17	22	19	20
derivatives	256	15	15	15	18	8	15
	270	11	11	12	11	6	11
	284	7	7	10	7	4	8
	298	6	5	8	4	2	5
	312	3	3	5	—	1	3
Dihydrope-	254	35	33	32	43	44	30
rylene and	268	30	27	26	24	29	29
alkyl deriva-	282	18	17	18	16	16	20
tives	296	9	10	11	9	8	11
	310	5	8	7	6	4	7
	324	3	5	5	—	—	4
Perylene	252	40	41	41	36	43	33
and alkyl	266	21	18	21	22	21	21
derivatives	280	14	14	15	15	15	16
	294	10	12	10	11	10	12
	308	7	9	7	8	6	9
	322	5	5	4	5	3	5
	366	3	3	3	3	2	3
Benzchry-	278	33	36	46	35	43	31
sene and	292	22	23	20	20	23	24
alkyl deri-	306	17	16	15	17	17	17
vatives	320	13	12	10	14	11	14
	334	9	8	6	6	6	9
	348	6	5	3	5	—	5
Anthracene	276	60	60	—	—	—	—
and alkyl	290	28	25	—	—	—	—
derivatives	304	11	10	—	—	—	—

Mass-spectrometric analysis was conducted by Mass-Spectrometer Varian MAT 711. A sample was directly injected into the ionization chamber of a mass-spectrometer ions source electron energy amount being 50 eV. The sample (less than 1 mg) was heated within 5 min. from the starting temperature of a system inlet up to about 300°C. Recording and decifering were conducted by the treatment of the data recorded on Varian SS 166. Component content was determined according to the peaks of the molecular ions with due regard for corrections of natural distribution of ^{12}C and ^{13}C isotopes using relative sensitivity indices that reflect relative probability of ion formation for different compounds [5].

The results of mass-spectrometric analysis of hydropyrolysates of tar and asphaltenes given in the Table show that mass-spectra reveal markedly detectable groups of ions characteristic to polycyclic aromatic hydrocarbons.

Groups of peaks characteristic to molecular and fragmentary ions, as well as the presence of peaks of double-charged (dicharged) ions certify the condensed aromatic character of these compounds and helped us to determine their molecular masses and the rate of hydrogenion saturation. Major part of these compounds are those with hydrogen unsaturation X up to 30 in the formulae C_nH_{2n-x}. But the precise nature of a coupling of cycles in a condensed system, place of addition of substituents, etc. could not be determined according to mass-spectra and the compounds were selected as probable ones among the possible structures.

The data of the Table show that the qualitative composition of hydropyrolysates of all the studied tars and asphaltenes is similar. In the hydropyrolysates of these compounds the structures of naphtalenem anthracene, pyrene, chrysene were predominantly identified including a small amount of aromatic structures with a great number of rings in their condensed system.

Mass-spectrometric analysis has shown that among aromatic hydrocarbons non-substituted and metal-substituted structures are prevailing in hydropyrolysates without their complete dealkylation. This is verified by distribution of peak intensities according to molecular masses (see Table) as well as the nature of distribution of the fragment ion peak intensities. Great probability of the processes of $(M-H)^+$ and $(M-CH_3)^+$ determined according to the nature of these distributions speak in favour of polymethylsubstituted structure of the compounds.

The obtained results show, that the method of autoclave hydropyrolysis elaborated by the authors might be efficiently used to determine aromatic fragments of tar-asphaltene compounds of oils.

Correlation of the results of the hydropyrolytic study of high-boiling aromatic hydrocarbons and tar-asphaltic compounds of oil enable us to assert that aromatic fragments of tar-asphaltic compounds of oil contain aromatic condensed systems similar to those present in high-boiling hydrocarbons of oil. Presence of similar structures of aromatic fragments in hydrocarbonaceous and tar-asphaltene portions of oil once more confirm the existence of genetic relationship between the afore-stated classes of compounds.

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PHYSICAL CHEMISTRY

V.Tsitsishvili, V.Chivadze

Study of Several Metal-Containing Applied Catalysts by Hydrogen Adsorption Method

Presented by Academician T.Andronikashvili, June 13, 1996

ABSTRACT. **Hydrogen adsorption-desorption processes on Pt-, Pd-, Ni-, Ni-Cu, and Ni-Cr-containing applied catalysts with gumbrin supporter have been studied.**

For Ni-, Ni-Cu, and Ni-Cr- containing samples hydrogen desorption takes place at low temperature with low activation energy (region I) and with high activation energy at high temperature (II). Two forms on bonded hydrogen with comparatively weak (I) and strong (II) coupling with the surface of the catalyst are created during adsorption. Differences in hydrogen desorption rate and Ni cristallite sizes (assessed by XPS method) explain the different activity of mentioned catalysts in hydration of citronellal.

Only strong-coupled hydrogen presents on the surface of Pt- and Pd-containing catalysts.

Recently PT-, Pd-, Ni-, Ni-Cu- and Ni-Cr- containing applied catalysts with gumbrin supporter have been studied in the reaction of citronellal hydration into citronellol [1]. The effect of a nature of the supporter in such reaction is connected both with hydrogen adsorption-desorption processes and the distribution of metal particles.

The interaction of hydrogen with metal active centers may be successfully studied by the method of hydrogen thermal desorption in a noble gas atmosphere controlled by a gas chromatographic analysis [2].

The data for several metal-containing gumbrin-supported catalysts received by the mentioned method are given in Table 1.

Table 1

Hydrogen thermal desorption in argon atmosphere for 1g gumbrin-supported catalysts

Metal content (%, mass)	$D(H_2)$ ml	*Desorption interval*			
		Region I			
		T_{max} °C	V ml	R ml/min	E ccal/mol
Ni (6.0)	2.1	430	0.5	0.30	38
Ni - Cu (5.9; 2.0)	3.2	310	1.5	0.30	29
Ni - Cr (5.8; 2.0)	8.4	200	1.0	0.16	21
	$D(H_2)$ ml	Region II			
		T_{max} °C	V ml	R ml/min	E ccal/mol
Ni (6.0)	2.1	540	1.5	0.20	47
Ni - Cu (5.9; 2.0)	3.2	430	0.9	0.35	38
Ni - Cr (5.8; 2.0)	8.4	525	6.0	0.95	44
Pd (0.5)	6.2	200-520	6.2		42
Pt (0.5)	1.8	380-600	1.8		40-50

$D(H_2)$ - total amount of desorbed hydrogen, ml;
T_{max} - temperature of maximal desorption, °C;
V - amount of desorbed hydrogen, ml;
R - hydrogen desorption rate, ml/min;
E - activation energy of hydrogen thermal desorption, ccal/mol.

The study of Ni-, Ni-Cu- and Ni-Cr- containing gumbrine-supported catalysts showed that hydrogen desorption takes place in two separated regions and the temperature of maximal desorption in this regions depends on the nature of the active metal.

The low values of activation energy of hydrogen thermal desorption for region I (E = 21-:-38 ccal/mol) are characteristic for a hydrogen form, which is in comparatively weak coupling with the surface of the catalyst. In the case of Ni-Cr-containing catalyst the thermal desorption of such form starts at comparatively low temperature (180-200°C) and has the lowest activation energy; but if the catalyst contains only Ni, then desorption takes place only above 400°C with the highest activation energy. The weakly bonded hydrogen on Ni-Cu-containing catalyst surface has an intermediate parameters in relation to the samples considered above.

For region II the values of activation energy of hydrogen thermal desorption and the high temperature of desorption are characteristic for a hydrogen form, which is in comparatively strong coupling with the suface of the catalyst. The presence of two different forms of bonded hydrogen on the surface of considered catalysts is conditioned by the nature of metals and the unhomogeneous matter of the catalyst surface [3].

The activation energy and the rate of hydrogen desorption are the main parameters that define the hydrogen state in the process of an organic compound hydration on the catalyst surface. For Ni- and Ni-Cu- containing samples the rate of hydrogen desorption is low (0.2 - 0.5 ml/min) in comparison with the rate for Ni-Cr- containing sample (0.95 ml/min), which is too high for successful transformation of citronellal into citronellol [1], the main product of citronellal hydration is 3.7-dimethyloctanol.

Table 2

XPS data for Ni- and Ni-Cu-containing gumbrin-supported catalysts

Catayst	$\Sigma Ni2P_{3/2}$ eV	$\Sigma Cu2P_{3/2}$ eV	$\Sigma Al2S$ eV	$\frac{INi}{IAl}$	$\frac{ICu}{IAl}$
Ni	856.3	—	75.7	1.61	—
Ni treated	856.3/852.4	—	75.7	1.60	—
Ni - Cu	856.2	931.8	75.8	0.92	0.45
Ni - Cu treated	855.8/852.2	931.4	75.8	0.92	0.45

$\Sigma Ni2P_{3/2}$, $\Sigma Cu2P_{3/2}$ and $\Sigma Al2S$ - energy of corresponding level, INi/IAl and ICu/IAl - Ni and Cu absorption line intensities ratio to intensity of Al reference line

The value of activation energy is connected with the size of metal crystallite on the catalyst surface and it may be very significant for the hydration reaction. Ni- and Ni-Cu- containing samples have been studied by XPS method (AEJ ES-100 spectrometer). The samples have been treated in the chamber of the spectrometer before spectra recording (20°C and 350°C, H_2 atmosphere). From the data obtained (Table 2) it may be concluded, that Ni in Ni- containing sample is presented in the form of small crystallites with diameter 15 - 20 Å, but the addition of copper enhances the crystallite size up to 60 - 70 Å.

For Pd- containing catalyst the process of hydrogen desorption is characterized by only one desorption region with T_{max} = 400°C and the high value of activation energy (42 ccal/mol); so the bonded hydrogen presents only in one form with comparatively strong coupling with the catalyst surface (region II by above used definition). It is

known, that the hydrogen form with a weak coupling presents in Pd- containing catalysts if the amount of Pd is sufficiently high (approximately 5%) [4]. The amount of hydrogen bonded on Pd- containing catalyst surface is high in comparison with Ni- and Ni-Cu- containing samples. With the use of Pd- containing catalyst the hydration of citronellal takes place in the direction of 3.7 - dimethyloctanal production [1].

Pt- containing catalyst exhibits nearly the same hydrogen adsorption peculiarities as Pd- containing sample, but due to the more broad temperature region of desorption without abruptness of maximum, the activation energy is assessed with lower accuracy.

It should be concluded that the hydrogen coupling energy on the surface of studied catalysts is in strong correlation with the direction of citronellal hydration. In this reaction both activity and the selectivity of catalysts are defined by the physical state of hydrogen adsorbded on the surface. The obtained data show the hydrogen adsorption on the different surfaces demonstrating the unhomogeneous nature of the surface for Ni-, Ni-Cu and Ni-Cr- containing catalysts.

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PHARMACEUTICAL CHEMISTRY

G.Mikaia, D.Turabelidze, N.Vulfson, Academician E.Kemertelidze

Deterpene Labden Diole from Shoots of *Juniperus Oblonga*

Presented July 18,1996

ABSTRACT. **Diterpene diole is extracted from *Juniperus oblonga* identified as (13E)-labd-13en-8x-15 diole and lignine lactone (-) Khibalactone.**

One of the most active vegetable compounds are terpenoids. The present work studies diterpene from *Juniperus oblonga* (*Cupresaceae* family). Air-dry ground shoots of Juniperus were extracted by methanol, dissolvent was drawn away and the residue was processed by chloroform. After thickening chloroform was chromatographed in the silica gel column in the hexane-benzol-ether gradient. Two individual crystal substances were separated. Compound and I m·t. 146-148°C; $[\alpha]_D^{20}$ -98° (c.I,O; $CHCl_3$); M^+352, $C_{20}H_{16}O_6$, according to IR-, UV-, IH - and ^{13}C NMR and also to mass-spectrometry appeared identic to the lignene lactone described in the literature (-) and to the earlier extracted one from *Anthriscus nemorosa* [1].

Compound II has 126-127°C; $[\alpha]_D^{22}$ - 2,3° (c. 0.8; MeOH), M^+308, $C_{20}H_{36}O_2$, in the IR spectrum absorption is absent. In the IR spectrum stripes appeared at 3600, 3130 and 1055 cm^{-1} corresponding to OH group and also at 1655,860^{-1} indicating one double link substituded three times.

'HNMR ($CDCl_3$, δ, m.p.): 0.795($3H_{-19}$,S); 0,80($3H_{-20}$,S); 0.875($3H_{-18}$,S); 0.95 ($2H_{-1}$,m); 1.07($1H_{-5}$, dd 1.5 and 3hz); 1.21($2H_{-2}$, dd, dd J 1.5 and 3hz); 1.40($2H_{-7}$,m); 1.43($2H_{-3}$,m); 145($1H_{-80H}$,m); 1.66(2H11, dd, dd, J 1.5 and 3hz); 1.69($3H_{-16}$,s); 1.84 ($1H_{-9}$, tr, tr 2 hz); 2.08($2H_{-12}$,m); 4.165($2H_{-15}$,m); 5.45($1H_{-14}$, tr, tr, J 1,5 hz).

Table 1

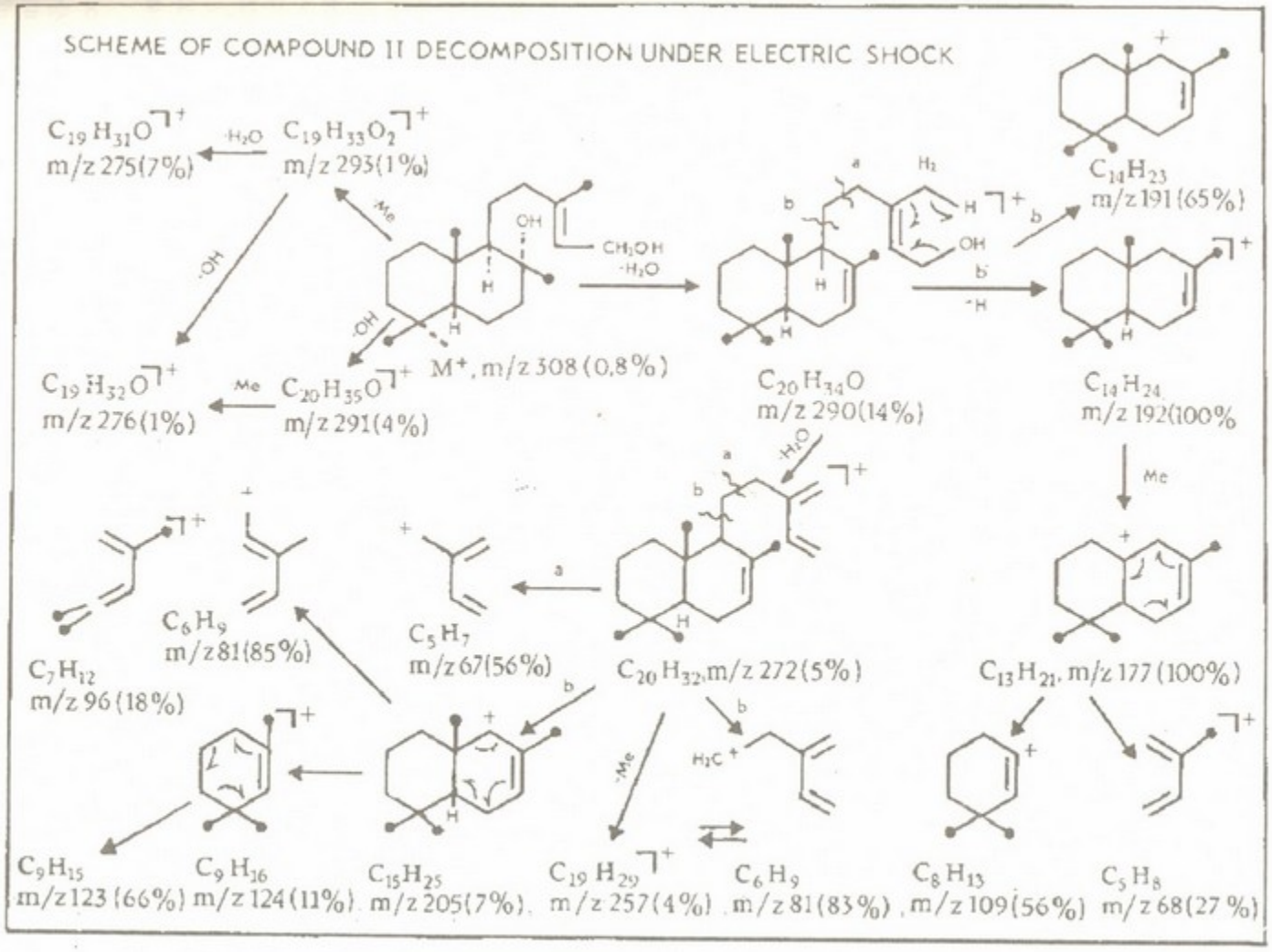
Some data of IH NMR spectra of II, III, IV compounds

C atom	II	III	IV
C-16	1.69(3H,s)	1.68(3H,s)	1.70(3H,d. J 1hz)
C-18	0.87(3H,s)	0.83(3H,s)	0.87(3H,s)
C-17	1.13(3H,s)	1.42(3H,s)	1.13(3H,s)
C-19	0.79(3H,s)	0.74(3H,s)	0.80(3H,s)
C-20	0.80(3H,s)	1.05(3H,s)	0.80(3H,s)

Acetizing of the compound II in pyridine and acetate anhydride at room temperature led to monoacetate formation as viscous mass with $[\alpha]_D^{22}$ + 6,86 (with I,16,MeOH) and in more strict conditions (while heating the mixture) - to diacetate $[\alpha]_D^{22}$ + 7.22 (c 0.83, MeOH). Acetizing rate was controlled according to IR spectra on UR-20 device in KB_r tablets.

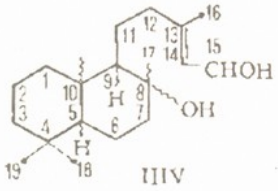
Mass-spectra were measured in "MAT" device (USA) and H and ^{13}C were registered on "Varian" - 500 (USA).

These data together with mass-spectral analysis (Table 1) closely coinciding with diterpene diole vulgarole (III) with $[\alpha]_D^{20}$ + 0, extracted from *Marrubium vulgare* (*Labiate* family) allowed to suppose that compound II also refers to diterpene-labdene diole type series [2,3].

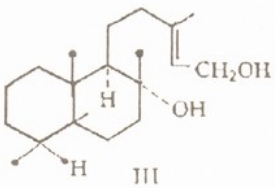

SCHEME OF COMPOUND II DECOMPOSITION UNDER ELECTRIC SHOCK
C19H31O+ m/z 275(7%)
-H2O
C19H33O2+ m/z 293(1%)
Me
OH
CH3OH -H2O
M+, m/z 308 (0,8%)
-OH
C19H32O+ m/z 276(1%)
Me
C20H35O+ m/z 291(4%)
C20H34O m/z 290(14%)
C14H23 m/z 191(65%)
C14H24 m/z 192(100%
Me
C13H21, m/z 177 (100%)
-H2O
C20H32, m/z 272(5%)
C5H7 m/z 67(56%)
C6H9 m/z 81(85%)
C7H12 m/z 96 (18%)
C9H15 m/z 123 (66%)
C9H16 m/z 124 (11%)
C15H25 m/z 205(7%)
C19H29+ m/z 257(4%)
C6H9 m/z 81(83%)
C8H13 m/z 109(56%)
C5H8 m/z 68(27%)

Existing difference of some methyle group signal positions in the I_H NMR spectra of II compounds and that of Vulgarole (III) (Table 1) proves their close identity and also allows to suppose that they are stereoizomeres as these substances differ by specific rotation.

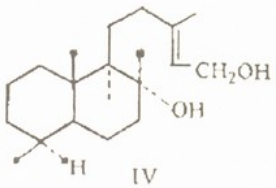
Diterpene diole (IV) is extracted from *Acacita species* (*Jegumianaseae* family) being identical with the above-mentioned (13E)-labd-13 en-8 15 diole with $[\alpha]_D^{20}$ - 5,0. Comparison of chemical shifts of prothone of methyl group compounds II and IV [4,5] (Table 1), 13_c NMI data (Table 2) and also indices of specific rotation showed their full identity. All above-mentioned proves consideration that compound II extracted by us is (13E)-labd-13 en-8α, 15 diole.



IIIV



III



IV

Table 2

^{13}C NMR spectra data of II and IV compounds

C atom	II	IV	C atom	II	IV
1.	39.83	39.9	11.	23.64	23.7
2.	20.60	20.6	12.	44.62	44.6
3.	42.04	42.1	13.	140.76	140.7
4.	33.32	33.3	14.	123.37	123.6
5.	56.18	56.3	15.	59.25	59.2
6.	18.48	18.5	16.	16.45	16.5
7.	42.92	42.9	17.	23.97	24.0
8.	74.12	74.2	18.	33.41	33.5
9.	61.25	61.3	19.	21.53	21.6
10.	39.28	39.3	20.	15.49	15.5

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GEOLOGY

M.Tkemaladze

Collector and Petroleum-Gas Accumulation Zones of the Eastern Georgia

Presented by Academician I.Gamkrelidze, June 3, 1996

ABSTRACT. **Taking as a basis new criteria in particular petrophysical and petrochemical investigations the petroleum containing units and collector zones in Mesozoic - Cainozoic sediments of Eastern Georgia have been separated and suitable recommendations have been given.**

The separation of petroleum content units and collector zones in Mesozoic-Cainozoic sediments of Eastern Georgia is based on well known and methodically new criteria, in particular petrophysical and petrochemical investigations.

Petroleum-gas accumulation zones are connected with large tectonic structures and collector zones - with stages, substages and stratigraphically more thin subdivisions. We marked out twelve zones of the collectors in the complex of the Cainozoic sediments of Eastern Georgian. The brief information about them is listed below in the following succession: the horizon of diffusion and area, the sorts of practically interesting fluid, the perspective in accordance with the potential, the prospecting quality and the other typical peculiarities .

1. **Paleocene sediments**. The areas of the collector zone diffusion: Samgori, Teleti, Rustavi and their environs; methane type gas; perspective in accordance with the potential; the study level of the prospecting is low. The productive strata are fixed in the boreholes: 11,12,13,23 (Telety), 3(Rustavi), 2(Tabori). The productive horizon has low stratigraphic position in the Paleocene section and is expressed by the carbonate suite (the thickness is equal to 500 m). It experiences the facial change in the direction of Samgori and Rustavi: the carbonate suite is substituted by terrigenous (sandstone – marl sediments). The gas flow was obtained at a depth interval of 4075-4005 m in the II-Teleti borehole (250000 m^3/t.f.h) (t.f.h. - twenty four hours).

2. **The Lower Eocene sediments**. Areas: Teleti, Samgori, Rustavi, Gachiani-Natsvaltskali structures. The productive gas accumulation strata are connected with the upper part of the Borjomi flish numullite carbonate and tuffaceous sandstones [1]. The gas accumulation of industrial long-range significance has fixed in the boreholes: Samgori- 3/130000 m^3/t.f.h./, 170,202; Rustavi 1,2/150000 m^3/t.f.h./, 3,30; Teleti - 11,13,19. They are potentially long-range. The level of studying is low.

3. **The Middle Eocene sediments**. The large-scale zone of the collectors. It territorially includes the petroleum layer which are in the state of intensive exploitation: Samgori -Patardzeuli - Ninotsminda, Teleti, the Samgori southern arch, Rustavi and the following prospecting areas: Lisi, Saburtalo, Varketili, Tabori. The productive strata are connected with the upper part of the Middle Eocene and practically interesting fluid is basically represented by the petroleum. There is perspective of the petroleum reserve rise. The level of studying is above the average.

4. **The Upper Eocene sediments**.

a) The areas: Teleti, Samgori-Patardzeuli, the Samgori southern dome, Ninotsminda, Rustavi, Kuparaantkhevi; petroleum - contained strata are connected

with intensively zeolited and chlorited rocks (basically polymictic sandstones) of the upper part of the Tbilisi suite. The reserves potential is low. They are in the research process.

b) The areas: Kavtiskhevi and its environs. The petroleum shows in a small quantity. The level of geological study is average.

5. **The Oligocene -Lower Miocene sediments**.

a) The areas: Kavtiskhevi, Goristsikhe, Uplistsikhe, Mukhrani. The petroleum shows in small quantity (Kavtiskhevi, Uplistsikhe). The zone is characterized by the high indexes of porosity (23%). The level of geological study is low.

b) The area of the zone diffusion is: Satskhenisi, Norio, Martkopi, Ujarma. Practically interesting fluid is basically petroleum. The midpart of the Middle-Maikop suite and Chokrak stage are comparatively perspective in the sense of accumulation potential of hydrocarbons (h.c.) and collector conditions. The Satskhenisi and Norio petroleum deposits are connected with them. The Satskhenisi petroleum is characterized by the high output of light fraction and the high content of cycle - aromatic hydrocarbons which evidently stipulates their high medical properties [1]. The level of the study is average.

6. **The Middle-Sarmatian sediments**.

a) The area of the collector zone diffusion: Mamcoda- Norio- Satskhenisi - Patardzeuli - Malkhazovka belt. The fluid is basically petroleum. The perspective by the potential is negligible, though the zone is characterized by high porosity, the effectiveness of the gas (Mamkoda) and surface petroleum display. The level of the study is low.

b) The areas: Patara Shiraki, Eldari, Baida, Taribani, Kila-Kupra. The zone is characterized by the optimum indexes of the collector parameters and the display of petroleum (Taribani, Patara Shiraki, Eldari, Baida) and gas (Kila-Kupra, Baida-Chatma). The average size and coarse -grained sandstone members are observed in the Iori shore belt specifically in Kriptomactre strata. The porosity and absolute permeability is high - accordingly equal to 18% and $400 \cdot 10^{-3}$ um^2 and higher.

7. **The Upper-Sarmatian sediments**. The large-scale zone of the collectors unites the following areas: Kiasamani, Patara Shiraki, Mirzaani, Taribani, Akhtatapa, Tulkiatapa, Katari, Kakbisdziri, Baida; the zone is characterized by high indexes of the collector parameters and the regional petroleum-gas saturation (Taribani, Kila-Kupra, Patara Shiraki, Mirzaani). The petroleum-gas surface displays in the Chobandagi-Mlashiskhevi belt are connected with the faults.

8. **The Meotian-Pontian sediments**. The large collectors zone unites the areas of Oleskhevi, Patara Shiraki, Baida, Iori, Taribani, Kushiskhevi, Nazarlebi, Mirzaani, Kala-Dari. The zone is connected with the clay-sandstone facies which is characterized by the high collector parameters and can be extended eastwards along the mentioned facies diffusion. The small petroleum deposits are exploited in the zone: Mirzaani, Patara Shiraki, Nazarlebi and there is relatively large-scale petroleum-gas accumulation in the Shiraki and Eldari suites. The perspective by potential is average. The Taribani keeping system has the signs of the primary retention and the petroleum-gas accumulation is epigenetic in the belt of Nazarlebi and Mirzaani and located in the secondary keeping system. The level of study is low.

9. **The Agchagil sediments**.

a) The areas of Mtsarekhevi deposit and Tsitsmatiani field. It is epigenetic petroleum. The Mtsarekhevi deposit is comparatively well investigated; b). The areas of Shavkabaskhevi, Shuamta, Cheremiskhevi, Turdo. The epigenetic petroleum is

connected with the lower part of conglomerate of the Alazani series. The level of the study is low. Generally speaking, the places of the overlap with the tectonic wedge of the Agchagil sedimentary basal conglomerates are comparatively perspective.

We list below the units of the petroleum-gas accumulation on the basis investigation of the Cainozoic sediments of the Eastern Georgia and the geological-structural peculiarities of formation of their basic deposits have been shown in the early work of the author [1].

We list the characteristics of the petroleum-gas accumulation zones and collectors in the Mezozoic sediments of the Eastern Georgia in the general form because of small number of the boring works.

We marked out the Vedzebi-Pkhoveli petroleum-gas accumulation zone and the Sioni-Kvareli gas accumulation subzone in the mountain Kakheti. The Vedzebi-Bakana and Pkhoveli-Gurjaani petroleum-gas accumulation subzones are marked out in the first above-mentioned zone. The Chvintauri, Ingeti, Shuagora, Vedzebi, Naduknari, Bakana areas and their environs are united in the Vedzebi-Bakana subzone. The basic perspective is connected with the Jurassic and Aptian-Albian sediments in the subzone. The keeping systems are of combined type, the Ildokani thrust and anticline structures (Vedzebi, Bakana, Shuagora) located in its nearness play the leading part in these systems. The petroleum samples are characterized by: the specific weight - 822-865 kg/m^3, the small content of sulphur (0.5%), the average content of paraffin (2.28-9.1%), relatively large output of the light fraction (42.6% Bakana). The petroleum extracted out of deeply located strata is more light. There is high content of the aromatic hydrocarbons in the benzine fraction. The following areas are united in the Pkhoveli-Gurjaani petroleum-gas accumulation subzone: Pkhoveli, Navtiskhevi, Papriskhevi, Gurjaani, Cheremi, Kvela-Tsmindakhevi, Kardanakhiskhevi, Mlashiskhevi, etc. The basic perspectives of the petroleum and gas are bound up with the Jurassic, Cretaceous and Oligocene sediments. The level of study by the boring work means is low. The 491 bore-hole in the Gurjaani region is relatively perspective. The surface petroleum is characterized by: the large specific weight (968 kg/m^3), the small content of the sulphur and the average one of paraffin; Methane-napthene hydrocarbones dominate in the group composition, though the high content of aromatic hydrocarbons is sometimes noticed. The petroleum extracted from the Akhtala medical volcanic mud by its physical-chemical characteristics (code) is similar to the petroleum extracted from the Oligocene sediments.

The Sioni-Kvareli gas accumulation zone contains the central part of the Alazani depression and partially its northern periphery. The level of its geological study is very low and its distinction is based on the analysis data (Sioni, Kvareli, Shuagora) of the methane type - gas and the geochemical coefficients (methanization, homologization) interpretation in the lateral direction taking also into account other geological considerations. The degree of Mesozoic rock metamorphism and catagenes in the subzone increases from the southern to the northern direction.

Generally speaking the southern and the north-western Alazani depression peripheries and their border belts are characterized by comparatively more good conditions for the petroleum-gas accumulation.

On the basis of the complex analysis of the petroporosity, petrophysical gas-petroleum physical-chemical and models prospecting in the mountain Kakheti, the following places require the investigation and estimation in the first instance: the Vedzebi deposit (in accordance with our interpretation) and Bakana, Gurjaani areas.

In the eastern part of the Achara-Trialeti zone we choose the large-scale zone of the collectors in the upper part of the cretaceous sediments of the Borjomi-Surami belt. It includes the Borjomi area and its environs. The south - east boundary supposedly lies through the Tsinaubani area and the north - west boundary - through the 29th borehole. The collector strata of this zone are characterized by the content of the hydrocarbonate-sodium and hydrocarbonate-sodium chloride stratum waters accompanied basically by the carbonic acid and rarely-carbonic acid-nitrogen and methane-hydrocarbonate type-gases. The rise of the methanization is noticeable in the stratigraphically low horisons.

Hence the deep drilling of wells must not generally be allowed (or sinking with the exceptional care) because there is danger of the mixing of abyssal methane gas-contained waters and Borjomi mineral waters and the decrease of their exploitation and export properties of the last ones.

The collector and petroleum-gas accumulation subzone is discovered in Pashiani, Kavtiskhevi and Akhalkalaki region areas. It is characterized by the petroleum display in a small quantity in the lower cretaceous sediments accompanied by the hydrocarbonate-nitrogen type gases. The collector parameters of the petroleum-gas contained strata are inadequate. The collector strata are characterized by high indexes of the porosity, they are basically water-contained ones and are marked out also in the upper cretaceous sediments.

The gas-contained strata are fixed in the petroleum-gas basin, in Tbilisi environs, in upper cretaceous sediments in the following boreholes: Teleti-55, Tbilisi-11(3198), Teleti-14(3726-3737). On its surface they are connected with the positive structures of the cretaceous sediments. But it is difficult to make the comprehensive conclusions about the collector and gas accumulation zones in the upper cretaceous sediments without boring works.

We marked out the collector and the petroleum-gas accumulation zone in the lower cretaceous sediments (the Khashuri -Kareli band) in the Kartli region of the Georgian block. The western and eastern lower zones are chosen in the boundaries of this zone. The western one contains the Vaka, Surami, Khashuri and Mokhisi areas and characterized by the methane-type gas accumulation, the eastern one (the Akhalsopeli, Agara and Kareli areas) - by the hydrocarbonate, hydrocarbonate-nitrogen and nitrogen-type gas accumulation. The petroleum-gas display is also fixed in this lower zone (Agara). The perspective abyssal intervals (the lower cretaceous, Jurassic) are not well investigated by the boring works on the Vaka, Khashuri and Morisi areas yet. On the other hand, there is the probability of the existence of the small-range and the average-range gas accumulation.

As a whole in the Eastern Georgia we marked out the following petroleum-gas district units: the petroleum-gas basin in Tbilisi environs with the petroleum-gas accumulation zone of the Tbilisi-Samgori rising block and the Norio-Satskhenisi, Rustavi-Natsvaltskali lower zones [1]. The petroleum-gas basin in the middle part of the Mtkvari depression with the outer Kakheti, the Iori shore elevation and the Gardabani-Palantekiani petroleum-gas accumulation zones; the mountain Kakheti petroleum-gas basin with the Vedzebi-Pkhoveli petroleum-gas accumulation zone and the Vedzebi-Bakana, the Pkhoveli-Gurjaani subzones and also the Sioni-Kvareli petroleum-gas accumulation subzone; the hydrocarbonate accumulation zone of the southern Kartli depression side with the Agara-Akhalsopeli petroleum-gas and Khashuri-Mokhisi gas - accumulation subzones; the Kavtiskhevi-Akhalkalaki petroleum-gas accumulation subzone. The geological-structural position of the hydrocarbonate accumulation in the Mesozoic complexes shows certain eccentricity in

relation to that in the Cainozoic complexes and points out in such a way the dissent of the structural plans. So the problem of the correction and analysis of the structural plans of the upper Jurassic, the lower cretaceous, the lower Eocene-Paleocene and other petroleum-gas contained on the roofs of the regional stages is actual.

The guiding principle of the existed scheme of the division into Georgian petroleum-gas districts requires notice and that's why the following units are baseless to-day: "The Kartli petroleum-gas district", where the results of the boring works are unsufficient or the "Dzhava-Pkhoveli potential petroleum-gas district", where we have the Vedzebi deposit and the abundance of the petroleum-gas displays.

The prospecting programmes require the correction. In particular, we must take into account the following questions during the process of choosing of the areas and the boreholes: the problem of the existence of the collector zones and the keeping systems (the prospecting boreholes must be located in the contours of such systems, which represent comparably localized areas); the complex of the criteria including the hydrogeological ones; the problems of the zone disposition of the petroleum-gas accumulation; the results of the bitumenological researches, the reduction-oxidation potential of the rocks, pH, etc.

The new programmes of the prospecting boreholes must provide the forced investigation and evaluation of the Paleocene, the Cretaceous, the Lower Eocene (free gas) and the Middle-Eocene, the Upper Sarmatian, Meotian-Pontian (petroleum and gas) large scale collector zones. The standard investigation of all listed collectors and petroleum-gas accumulation zones (subzones) must be carried out. At the same time the Georgian special prospecting programme must be worked out for the gas deposits and intensive displays of different types. The geological formations of all types must be investigated and evaluated as well.

We consider the mentioned measures realization as one of the primary ways out of the arised petroleum-gas crisis situation.

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PETROLOGY

A.Okrostsvaridze

The First Data of Gas Chromatographic Research in Hercynian Granitoids of the Great Caucasus

Presented by Corr. Member of the Academy G.Zaridze August 3,1996

ABSTRACT. **Gas chromatographic research, carried out in the hercynian granitoid of the Great Caucasus shows that all genetic types of granitoids contain gases of different quality and composition. Their main contents are represented by H_2O, CO, CO_2, CH_4 and N_2. According to N/C parameter the rocks of gabbro-plagiogranite series belong to oceanic crust formations, but plagiogranite-granite and granitoid alaskite - to continental. Granitoids of gabbro-adamellite series represent both oceanic and continental crust formations.**

In folded system of the Great Caucasus hercynian granitoids appear in four laterally zonal plutonic series, which are arranged from oceanic to continental crust (from the South to the North) in the following order: 1) gabbro-plagiogranite; 2) gabbro-adamelite; 3) plagiogranite-granite (granite-migmatite); 4) granodiorite-alaskite [1]. In order to develop a petrogenetic model of these granitoids we also studied fluidal condition of their origin. We used two methods – cryometric method of investigation of gas-fluid inclusions and gas chromatographic (thermal activity) method. The results of the first one have already been published [2]. In this article we bring forward the results achieved by the second method.

Gas chromatographic tests in hercynian granitoids of the Great Caucasus were carried out at the Institute of Precambrian Geology and Geochronology of Saint-Petersburg. The setting has a sample inserter and quartz reactor with a heater, which can rise the level of temperature up to 1300°C with velocity of 10°C per minute. Mass-spectrometer provides us with an opportunity to carry out continuous tests on the released gas on the following contents: H_2O, CO_2, CH_4, C:H:, H_2, CO_2, N_2, SO_2, O_2, H_2S. The whole process of the test is automatized and the inaccuracy of the results does not exceed 5% limit (3).

The tests carried out on hercynian granitoids of the Great Caucasus by gas chromatographic method show that according to their composition and quality they are strictly different from each other. As we can see from the table, the quality of gas phase is high in plagiogranites of gabbro-plagiogranite series, which is determined by high proportion of H_2O. In plagiogranites of Blibi massif H_2O/CO_2 parameter is close to 22, but in plagiogranites of Kamenistaia this ratio is higher than 10.

It is a common knowledge that N/C parameter ($N = 2N_2$; $C = CO_2 + CH_4 + 3C_X$) for the rocks of the continental crust ranges within the interval of 0.15-0.5, but for the oceanic crust it is lower than 0.15 (4). According to this parameter plagiogranites of Blibi massif are attributed to the formations of oceanic crust, but Beshta and Kamenistaia to continental crust.

In granitoids of gabbro-adamellite series bulk composition of gas does not exceed 2.8 ml/gr and is far lower than in plagiogranites of gabbro-plagiogranite series. In these granitoids the proportion of H_2O is reduced and H_2O/CO_2 ratio does not exceed 3.3. According to gas content in the granitoids of this series, Dariali and Kasari massifs on the one hand and Sakeni intrusive and Agekhi massif on the other hand bear resemblance. The situation is the same in these massives according to N/C parameter

Table

Gas contents (ml/gr) and some parameters in the hercynian granitoids of the Great Caucasus

Sample N	H_2O	CO_2	CH_4	C:H:	H_2	CO	N_2	SO	H_2S	ε	N/C	H_2O/CO_2
1	2	3	4	5	6	7	8	9	10	11	12	13
Gabbro-Plagiogranite Series												
1221	3.461	0.358	1.104	0.014	0.052	0.859	0.116	0.0002	0.0005	5.016	0.228	9.9
1326	3.527	0.312	0.089	0.18	0.047	0.741	0.137	0.0002	0.0007	4.876	0.232	11.3
66-I	10.558	0.483	0.039	0.005	0.003	0.650	0.047	0.0003	0.0001	11.792	0.081	21.9
88-I	8.365	0.502	0.026	0.005	0.005	0.787	0.059	0.0002	0.0001	9.505	0.074	7.8
Gabbro-Adamellite Series												
186	1.193	0.402	0.057	0.010	0.072	0.535	0.108	0.0006	0.0005	2.469	0.347	2.7
819	1.102	0.313	0.059	0.007	0.082	0.518	0.143	0.0008	0.00033	2.224	0.311	3.3
2743	1.079	0.670	0.048	0.013	0.809	0.301	0.053	0.0001	0.0001	2.980	1.121	1.6
2882	1.055	0.552	0.029	0.011	0.577	0.461	0.087	0.0008	0.0008	2.754	0.114	1.9
Migmatites of Plagiogranite-Granite Series												
125	0.660	0.142	0.158	0.100	0.059	0.396	0.081	0.0001	0.0003	1.407	0.352	4.7
214	0.885	0.176	0.049	0.010	0.022	0.576	0.175	0.0003	0.0003	1.946	0.396	5.1
966	0.951	0.222	0.036	0.010	0.018	0.451	0.073	0.0001	0.0009	2.176	0.198	4.3
2315	0.788	0.189	0.059	0.013	0.032	0.675	0.129	0.0005	0.0004	1.765	0.498	4.9

1	2	3	4	5	6	7	8	9	10	11	12	13
Plagiogranites of Plagiogranite-Granite Series												
33	0.700	0.438	0.055	0.012	0.033	0.654	0.236	0.0006	0.0003	2.134	0.398	1.6
332	0.902	0.342	0.048	0.010	0.026	0.544	0.121	0.0002	0.0007	1.974	0.205	2.8
984	0.707	0.376	0.037	0.008	0.021	0.380	0.139	0.0001	0.0003	1.672	0.265	1.9
2818	0.880	0.614	0.054	0.011	0.033	0.652	0.182	0.0001	0.0001	2.432	0.175	1.2
Porphiroblastic Granites of Plagiogranite-Granite Series												
850	2.0.62	0.190	0.062	0.016	0.032	0.958	0.119	0.0007	0.0003	3.279	0.109	10.8
2044	3.047	0.274	0.147	0.015	0.043	1.455	0.154	0.0016	0.0003	5.137	0.223	11.1
2063	5.450	0.325	0.099	0.039	0.034	1.307	0.103	0.0012	0.0003	7.312	0.202	16.2
Granite-Diorite Alaskite Series												
615	2.876	0.316	0.990	0.020	0.018	1.146	0.154	0.0037	0.0001	4.627	0.214	9.1
972	2.116	0.292	0.096	0.022	0.021	1.067	0.177	0.0006	0.0005	3.798	0.233	7.9
2352	2.900	0.375	0.100	0.017	0.026	1.139	0.204	0.0003	0.0002	4.995	0.245	7.8

Sample 1221 is from Kamenistaia Massif; sample 1326 - Beshta massif; sample 186 - Marukhi Massif; sample 819 - Sakeni intrusive; sample 2743 - Dariali Massif; sample 2882 - Kasari Massif; samples 75 and 125 - r.Klichi gorge; samples 859, 966, and 984 - r.Gvandra gorge; sample 2617 - r.Ulu-Murgu gorge; sample 33 - r.Klichi gorge; sample 332 - r.Sakeni gorge; sample 2818 - r.Nakra gorge; samples 2644 and 2063 - r.Nakhari gorge; sample 2352 - r.Dauty gorge; samples 66-I and 88-I - Blibi Massif (collection of I.Mgaloblishvili).

as well. In granites of Dariali and Kasari it corresponds to 0.121, and 0.114, which is characteristic of oceanic crust formations. In granitoids of Agekhi massif and Sakeni intrusive N/C parameter corresponds to 0.314 and 0.347, which indicate that they are formations of continental crust.

Chromatographic research gives quite a clear picture in plagiogranite-granite series. As we can see from the table, in the substratum (in migmatites of regional extention) chemical quality of gases is low and does not exceed 2 ml/gr. This parameter is five times lesser than in plagiogranites of gabbro-plagiogranite series, but the proportion of CO_2 is increased in them. H_2O/CO_2 parameter does not exceed 5.3 in migmatites, while in plagiogranites of gabbro-plagiogranite series it reaches 22. As to N/C parameter in migmatites it corresponds to the data of continental crust (~0,30). In plagiogranites of plagiogranite-granite series as compared to plagiogranite-migmatites, the total amount of gases does not change, but the increase of CO_2 proportion is clear. Here H_2O/CO_2 decreases to 28, which quite corresponds with the results of cryometric research. N/C parameter corresponds to the data of continental crust both in migmatites and plagiogranites.

In porphyroblastic granites of plagiogranite-granite series and also in binary granites of granitoid-alaskite series a sharp increase of gas phase is registered. In binary granites, as compared to plagiogranites, it increases twice, but in porphiroblastic granites three times. In binary granites the average level of gases reaches 4.6 ml/gr., but in porphiroblastic - 5.2 ml/gr. As compared to plagiogranites H_2O increases and CO_2 decreases in fluids of these rocks. The average level of H_2O/CO_2 is 8.2 in binary granites, but in porphiroblastic-12.7. As we can see there is a general tendency towards increasing of gases in binary and porphiroblastic granites, but in the latter one this process is more conspicious. It is quite possible, that high quality of fluids in porphiroblastic granites cause delayed growth of microcline. According to N/C parameter these granites are formations of continental crust.

So, chromatographic research of hercynian granitoids of the Great Caucasus has shown that each genetic type of granitoids contain gases of different type and quality. Namely plagiogranites of gabbro-plagiogranite series are notable for the highest composition of gas phase(>15 ml/gr.), which is determined by high proportion of water. For these rocks H_2O/CO_2 exceeds 20, as for other granitoids these data are far lower. In granitoids of gabbro-adamellite series the total amount of gases is low and it's not more than 2.8 ml/gr. The proportion of water abruptly decreases in these rocks and H_2O/CO_2 parameter ranges in the interval of 1.2-2.8. The leap of fluid phase is present in porphyroblastic granitoids. As compared to plagiogranites it increases three times. At the same time decreasing of CO_2 is present. The total amount of gases is also high (4.5 ml/gr.) in granodiorite-alaskite series, here like porphyroblastic granites the proportion of water is low.

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MINERALOGY

B.Tutberidze, R.Akhvlediani

Composition Features and Thermodynamic Conditions of Amphibole Formation of Some Young (Neogen-Quaternary) Volcanites of the Caucasian Transversal Uplift (in the Georgian Boundaries)

Presented by Academician N.Skhirtladze, May 27, 1996

ABSTRACT. **For the first time new data are given on amphiboles from neogen-quarternary age volcanites of the Caucasian transversal uplift in the Georgian boundaries.**

Chemical and minal content, crystal-chemistry of mineral individuals are studied. On this base several isomorphic types of amphiboles are distinguished. The main distribution of it has pargasite-hastingsite. Thermodynamic parameters of mineral formation are calculated by the content.

Today there is a rather rich material about the amphiboles of young age volcanites, distributed in many regions of the planet. But the same can't be said about the amphiboles distributed in volcanites of the Caucasian transversal uplift which are not specially studied till now.

Amphibolcontaining rocks of the studied region are: andesites, dacites and riolites in which this material is rockforming. In basal lavas (dolerites, basaltes) they meet very rarely or are completely absent.

The chemical composition of the amphiboles has been studied with microprobe analyser and the obtained results are summarized in the Table.

As seen from the table components in the studied amphiboles changed in narrow limits generally through there were exeptions for example in case of Al_2O_3, Fe_2O_3 and FeO.

Though studied amphiboles as a rule are characterized by heightened aluminiferousness (Al_2O_3 = 9 - 14%) but sometimes its content is very low (5-7%) (analyses 8, 10, 23, 24). Attention is paid to both composite variations in wide limits and to its high content (TiO_2 = 1 - 4%). By this component composition studied amphiboles come closer to basaltic hornblende than to kaersutite. As it is known content of TiO_2 in the last is rather high and varies in the wide range (4 - 12%). Considerable parts of amphiboles are characterized by high significance ratio of ferrous and ferric oxide. As a result the mentioned hornblends in general can be refered to the group of "oxidized" or basaltic amphiboles.

The studied amphiboles are also characterized by high content of Na_2O (up to 3%). Because of this they are wholly identified as amphiboles of oceanolitic metaophiolite core.

The picture of each component figurative point change in amphiboles is easily expressed by two component diagrams of S. Korikovski: a_{ca} - a_{si}; a_{si} - a^3_{vi} [1].(Fig.1).

The diagrams with clean chemism of amphiboles show two groups: for the first amphiboles group it is typical the ratio Al/Al^{iv} = 0.94-1.3 form/unit in tetrahedral radical siliceousness a_{Si} = 11.75-16,37 and low values of aluminiferousness coefficient though they have high values of Si/Al dependence (5.40-6.90). Figurative points

characterizing the mineral chemism of given amphibole group are located in the field of usual and edenite hornblendes series.

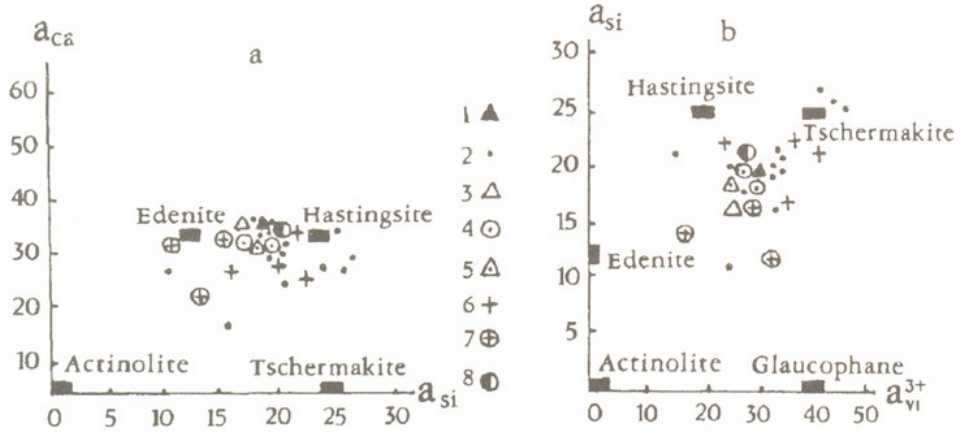

Fig 1. Young volcanite amphiboles of Caucasian transversal uplift a_{Ca}-a_{Si} (a) and a_{Si}-a_{VI}^{3} (b) diagrams (by Korikovsky).
note: amphiboles from: 1. Miopliocene andesite; 2. Miopliocene dacite; 3. Miopliocene riolite (South Georgia); 4. Pliocenquarternary basalts (Georgian platform); 5. Middle pleistocene andesite; 6. Young pleistocene andesite; 7. Young pleistocene dacite; 8. Hologene riolite (Caucasian south side folding system).

For the second amphibole group, the great number of analyzing samples are characterized by tetrahedral coordination heightened content (Al/Al_{4+}=1.30-2.09 f/unit); they show high degree of substitution $Al^{3} \rightarrow Si$ (a_{Si} = 16-26), high alumino-ferousness coefficient (K_{Al} = 12-17) and low Si/Al ratio (2.93-3.72) values. Figurative points of the given amphibole group chemism are located in the field of hastingsite and tschermakite hornblendes series.

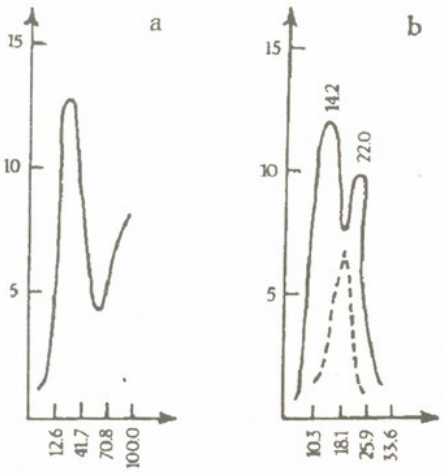

Fig.2. Young volcanite amphiboles of the Caucasian transversal uplift
a) oxidation and
b) potassiosness hystohrams

Chemical composition change of the studied amphiboles is sharply defined on the classification diagram offered by W.Dir with co-authors [2]: $[Al]^{4}$-$[Al]^{6}$+Fe+Ti; Ca+Na+ Na-Al. On these diagrams the most figurative points of amphibole chemism are grouped together in the field of hastingsite-pargasite hornblende series and less one - in tschermakite and edenite.

Preparation of the data of amphibole chemical composition by the statistic method showed normal law of separate oxide distribution except Fe^{2+} which may be used as oxidizing potential variation index during volcanogenic process evaluation.

On the basis of oxidizing potential coefficients pottasiousness calculated for amphiboles histograms were plotted (Fig 2).

As it is seen from the given diagrams two distinct maxima are fixed - 27.0 up to 100% - on hystograms of oxidizing ratio change (Fig 2,a).

Chemical compositions of the amphiboles and crystolochemical formulae

№	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Si	Ti	Al^{IV}	Al^{VI}	Fe^{3+}	Fe^{2+}	Mg	Ca	Na	K
1	42.15	3.08	10.88	6.67	7.69	0.27	13.08	10.64	2.72	0.89	6.47	0.35	1.53	0.45	0.77	0.99	2.99	1.75	0.81	0.17
2	41.37	1.89	10.91	6.60	0.00	0.29	12.07	10.70	2.77	0.54	5.97	0.21	1.86	0.00	1.81	0.00	2.60	1.66	0.78	0.10
3	41.03	2.97	12.59	14.77	0.00	0.16	12.20	11.17	2.09	0.50	5.91	0.32	2.09	0.05	1.60	0.00	2.62	1.72	0.58	0.09
4	42.34	2.36	11.54	8.18	6.28	0.00	13.62	10.52	3.05	0.35	6.46	0.27	1.54	0.53	0.98	0.80	3.02	1.72	0.90	0.07
5	42.09	2.48	11.76	8.28	6.05	0.10	13.61	10.56	2.94	0.41	6.42	0.28	1.58	0.53	0.95	0.77	3.00	1.73	0.87	0.07
6	42.07	2.58	11.65	8.60	6.00	0.18	13.03	11.60	2.52	0.56	6.39	0.29	1.61	0.47	0.92	0.76	2.95	1.83	0.74	0.05
7	42.35	1.96	11.10	6.35	8.26	0.15	13.04	10.94	3.10	0.57	6.52	0.23	1.48	0.54	0.73	1.06	2.99	1.81	0.92	0.11
8	46.49	1.21	6.74	8.75	5.93	0.56	14.76	11.04	2.05	0.40	7.06	0.14	0.94	0.27	1.00	0.75	3.34	1.80	0.61	0.08
9	45.82	2.04	9.52	5.81	9.94	0.14	14.78	8.64	2.00	0.50	6.30	0.21	1.54	0.00	0.60	0.14	3.08	1.27	0.53	0.08
10	46.22	1.65	6.55	14.01	2.21	0.40	14.04	11.29	1.03	0.52	6.69	0.18	1.13	0.00	1.53	0.25	3.03	1.75	0.29	0.09
11	43.81	2.87	10.96	11.06	0.00	0.23	14.96	11.52	1.73	0.42	6.93	0.31	1.77	0.07	1.18	0.00	3.06	1.76	0.48	0.08
12	41.21	1.75	11.46	18.08	0.00	0.39	11.61	10.72	1.78	0.74	6.00	0.19	1.98	0.00	1.97	0.00	2.52	1.67	0.50	0.14
13	41.70	3.00	12.56	8.19	3.13	0.27	14.86	10.89	2.81	0.51	6.30	0.34	1.70	0.70	0.93	0.39	3.34	1.76	0.82	0.10
14	41.51	3.46	11.78	4.68	7.82	0.25	13.56	11.13	3.04	0.60	6.37	0.40	1.63	0.49	0.54	1.00	3.10	1.83	0.90	0.12
15	43.23	3.08	9.86	6.99	6.38	0.46	14.05	10.48	2.82	0.82	6.58	0.35	1.42	0.35	0.80	0.81	3.19	1.71	0.83	0.16
16	42.19	2.20	12.00	7.38	4.13	0.00	14.97	11.70	3.03	0.40	6.39	0.25	1.61	0.55	0.84	0.52	3.38	1.80	0.91	0.07
17	41.72	2.03	11.76	6.61	8.58	0.00	12.51	11.18	2.82	0.43	6.43	0.24	1.57	0.58	0.77	1.11	2.87	1.84	0.85	0.08
18	42.58	2.10	11.19	6.58	8.50	0.31	12.77	10.82	2.94	0.38	6.55	0.24	1.45	0.58	0.76	1.03	2.86	1.78	0.87	0.07
19	40.04	4.55	14.33	2.81	7.96	0.12	13.33	11.50	2.68	0.92	6.12	0.52	1.88	0.70	0.28	1.02	3.04	1.88	0.79	0.18
20	43.79	2.85	11.29	13.21	0.00	0.16	12.17	11.42	2.14	0.68	6.27	0.31	1.73	0.18	1.42	0.00	2.60	1.75	0.59	0.13
21	42.16	3.13	12.07	13.09	0.00	0.27	13.13	11.30	1.82	0.58	6.05	0.34	1.97	0.07	1.41	0.00	2.80	1.74	0.50	0.11
22	45.80	3.68	10.70	10.56	2.08	0.00	15.86	9.47	2.00	0.50	6.70	0.29	1.30	0.58	1.16	0.25	3.45	1.48	0.57	0.00
23	42.64	1.12	5.24	8.27	9.46	0.16	15.09	13.84	1.86	0.28	6.70	0.13	0.07	0.00	0.98	1.25	3.54	2.33	0.57	0.07
24	46.47	1.25	7.261	1.29	3.64	0.29	14.63	9.47	2.26	0.36	7.04	0.14	0.96	0.33	1.28	0.46	3.30	1.61	0.66	0.07
25	44.58	2.47	10.80	7.57	4.38	0.00	14.85	10.57	2.55	0.36	6.69	0.28	1.31	0.56	0.85	0.55	3.32	1.70	0.74	0.07
26	41.40	4.07	13.07	4.18	7.32	0.17	13.18	10.75	2.84	0.64	6.32	0.47	1.68	0.67	0.48	0.97	2.99	1.76	0.84	0.12

Note: amphiboles from: 1. Javakheti ridge miopliocence andesite; 2-9. Samsari ridge miopliocene dacite; 10-14. Erusheti ridge miopliocene dacite; 15. Javakheti ridge miopliocene riolite (South Georgia); 16-17. Pliocene-quarternary basalts (Georgian platform); 18. Volcano Small Nepiskalo middle pleistocene andesite; 19. Volcano million young pleistocene andesite; 20-22. Plateau Keli young pleistocene andesites; 23-24. Volcano Kasbegi young pleistocene dacites; 25. Volcan Kabardjina young pleistocene dacite; 26. Volcan Didi Nechiskalo riolite (Caucasian south side folding system).

As to potassiousness coefficient on hystograms two maxima are also fixed in the range of 14.2 and 22.0% (Fig. 2,b).

Determination of minal composition revealed most compound nature of the studied amphiboles. Two independent isomorphic series were determined: edenite-pargasite-hastingsite-schermakite and tremolite-pargasite with high content of tremolite (rich with Mg).

Making the calculations of amphiboles on mineral components contemporary ideas were taken into account about presence of the so-called "biopirabola" molecule in the structure of amphiboles.

By our opinion the presence of potassium molecule in the analyzed samples should be used as transition index of the studied series of amphiboles to the stratified structures. The mentioned process is confirmed by observation phenomenon of chloritization and biotite and seladonite minals presence in amphiboles.

On the base of contemporary heothermometre calculations we try to determine thermodynamic conditions of amphiboles crystallization. As it follows from investigated data formation of amphiboles have taken place in the conditions of high pressure (p=10-16 kbar).

It concludes the following:

1. Analysing above mentioned factual material in amphiboles from neogen-quaternary volcanites of the Caucasus transversal uplift two isomorphic ranges have been established: a) edenite-pargasite-hastingsite-tshermakite and b) tremolite-pargasite.

2. Studied amphiboles in spite of differences in age and petrographic composition of enclosing rocks and also forms of the inclusions and degrees of colour changing wholly belong to the calcium amphibole group (Ca=1.27-2.38 funit; Na+K=0.38-1.02 funit).

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METALLURGY

Yu.Kartvelishvili, V.Garibashvili

Study of Composite Antirust and Wear Resistant Coatings

Presented by Academician G.Gvelesiani May 27, 1996

ABSTRACT. **The plasmatic and detonation coatings from the composite powders NiCr + Cr_3C_2 and from the mechanical mixture of powders of the same composition have been investigated. The structures of coatings from the composite powders are more dense, with regular distribution of carbide particles, which cause their higher strength of adhesion and higher wear resistance**

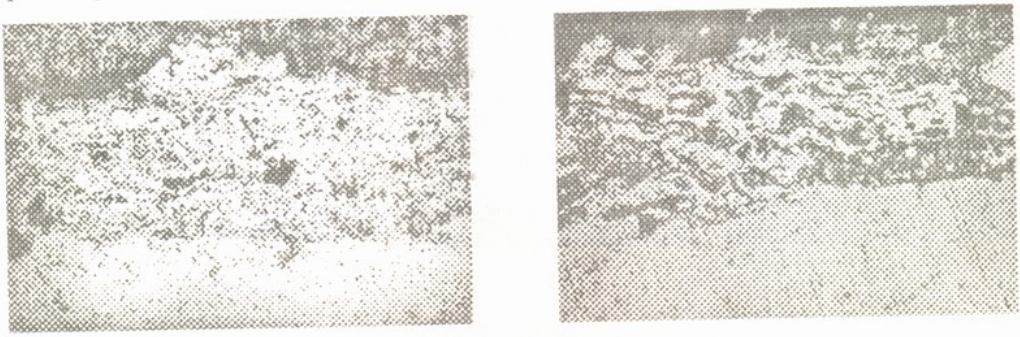
Duration in-service time of parts is one of the most important task in machine-building. High-temperature corrosion and wear are principal factors limiting the service time of a number of assemblies of engines and units. At present the problem of protection of unit surfaces has been successfully solved by use of powder coatings by means of modern methods of gasothermal spraying such as plasmatic and detonation ones. Coatings obtained by the stated methods differ in quality from all the others used previously. Here the structure is more dense and low-porous ensuring high protective efficiency of backing. Besides, the stated methods keep to obtain high bonding strength between the cover – coating and backing.

Plated or composite powders consisting of metal backing, stable heat and corrosion resistant, dispersed with particles of very hard refraction phase have been frequently used as materials for heat- and wear-resistant surfaces.

The present paper deals with the study of coatings from the composite powders obtained by the authors constituting nickel-chromium alloy plus 20% of chromium carbide – Cr_3C_2. For comparison, coatings of mechanical mixture of powders of nickel-chromium and chromium carbide of the same composition were investigated. The coatings were applied by the method of plasmatic and detonation spraying. For plasmatic spraying, the powders were used with characteristic dispersity of 50-100 mk.

Structural and phase composition of the coatings were studied by metallographic and microroentgenospectral analysis on the optic microscope "Neophot 21" and the analyser MS-46 of "Cameca".

Figs. 1 and 2 present microstructures of plasmatic and detonation coatings from composite powders NiCr-Cr_3C_2 and from the mechanical mixture of powders of alloy



a b

Fig. 1. Microstructure of plasmatic coatings of NiCr+Cr_3C_2: a) of composite powder; b) of mechanical mixture, x 400.

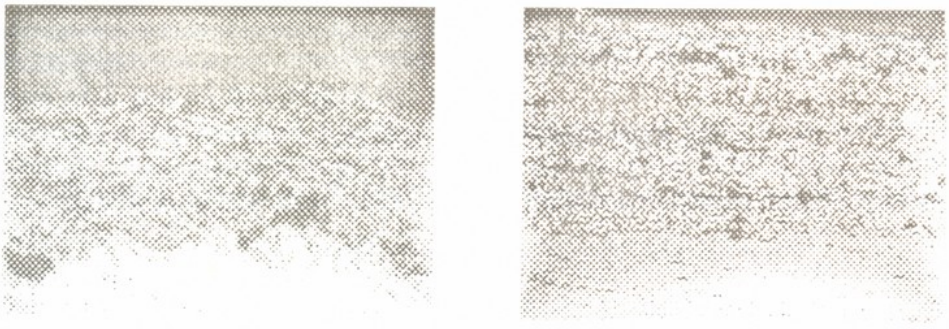


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Fig. 2. Microstructure of detonation coatings of $NiCr+Cr_3C_2$: a) of composite powder; b) of mechanical mixture, x 400.

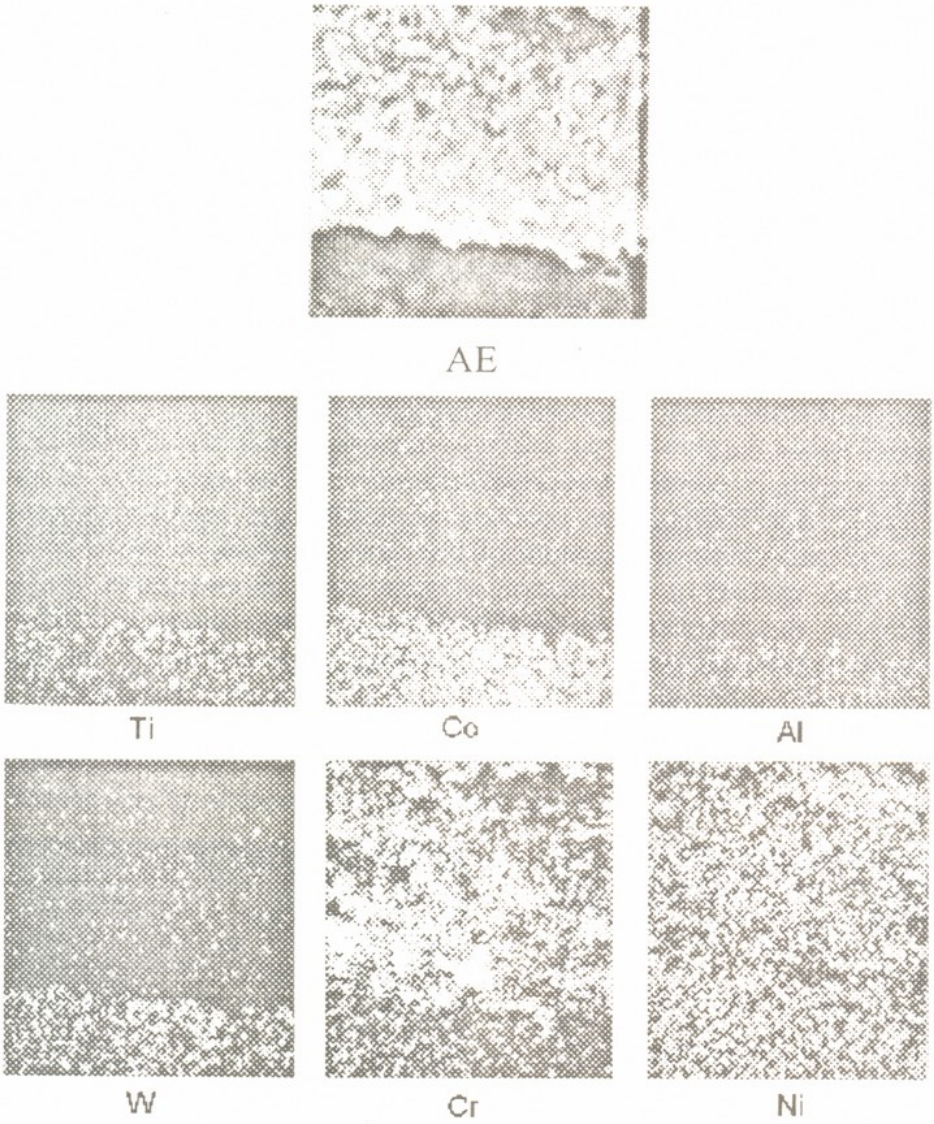

Fig. 3. Images of plasmatic coating of composite powder $NiCr+Cr_3C_2$ in absorbed electrons (AE) and characteristic roentgen rays.

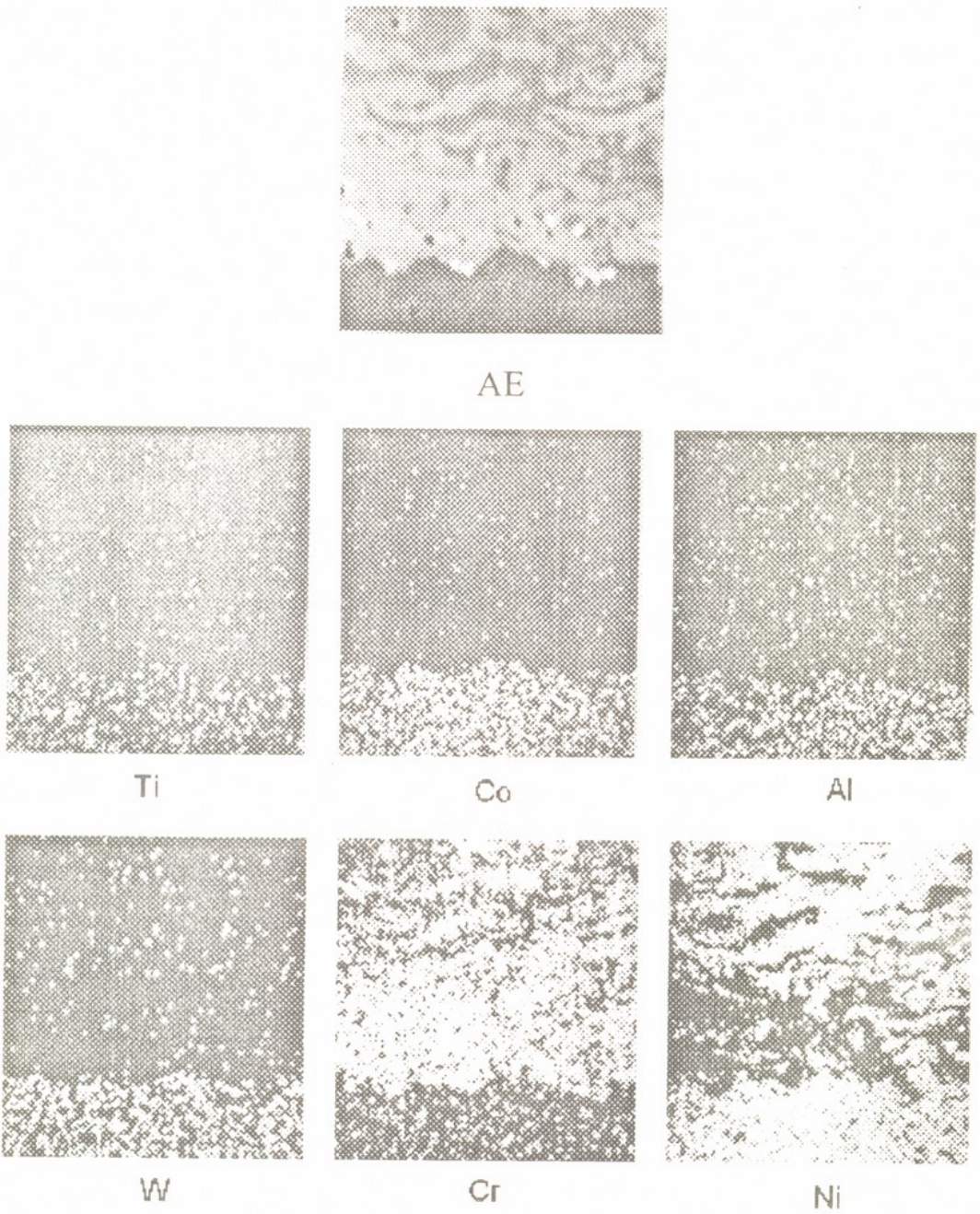

Fig. 4. Images of plasmatic coating of mechanical mixture of powders NiCr + Cr_3C_2 in absorbed electrons (AE) and characteristic roentgen rays.

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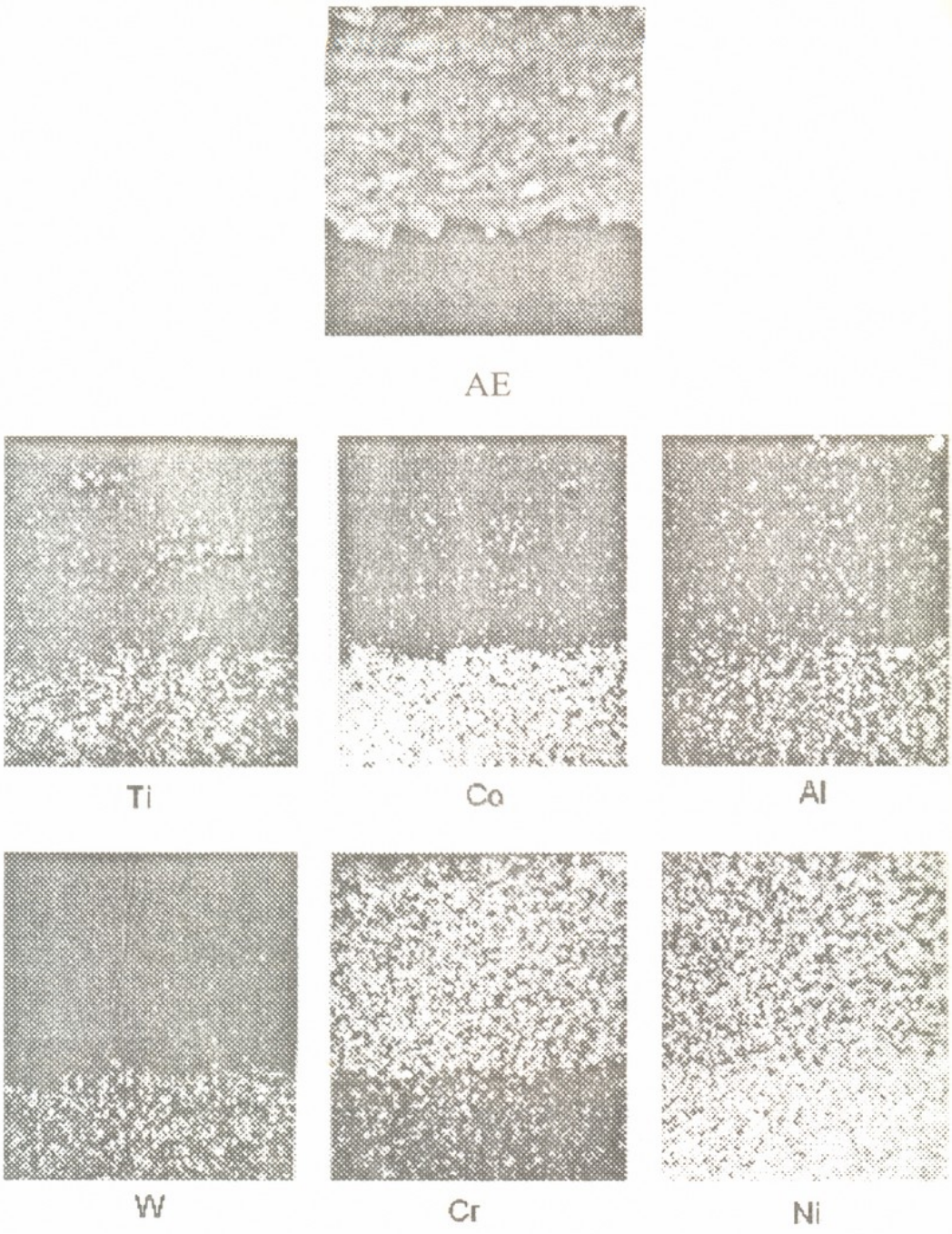

Fig. 5. Images of detonation coating of composite powder $NiCr+Cr_3C_2$ in absorbed electrons (AE) and characteristic roentgen rays.

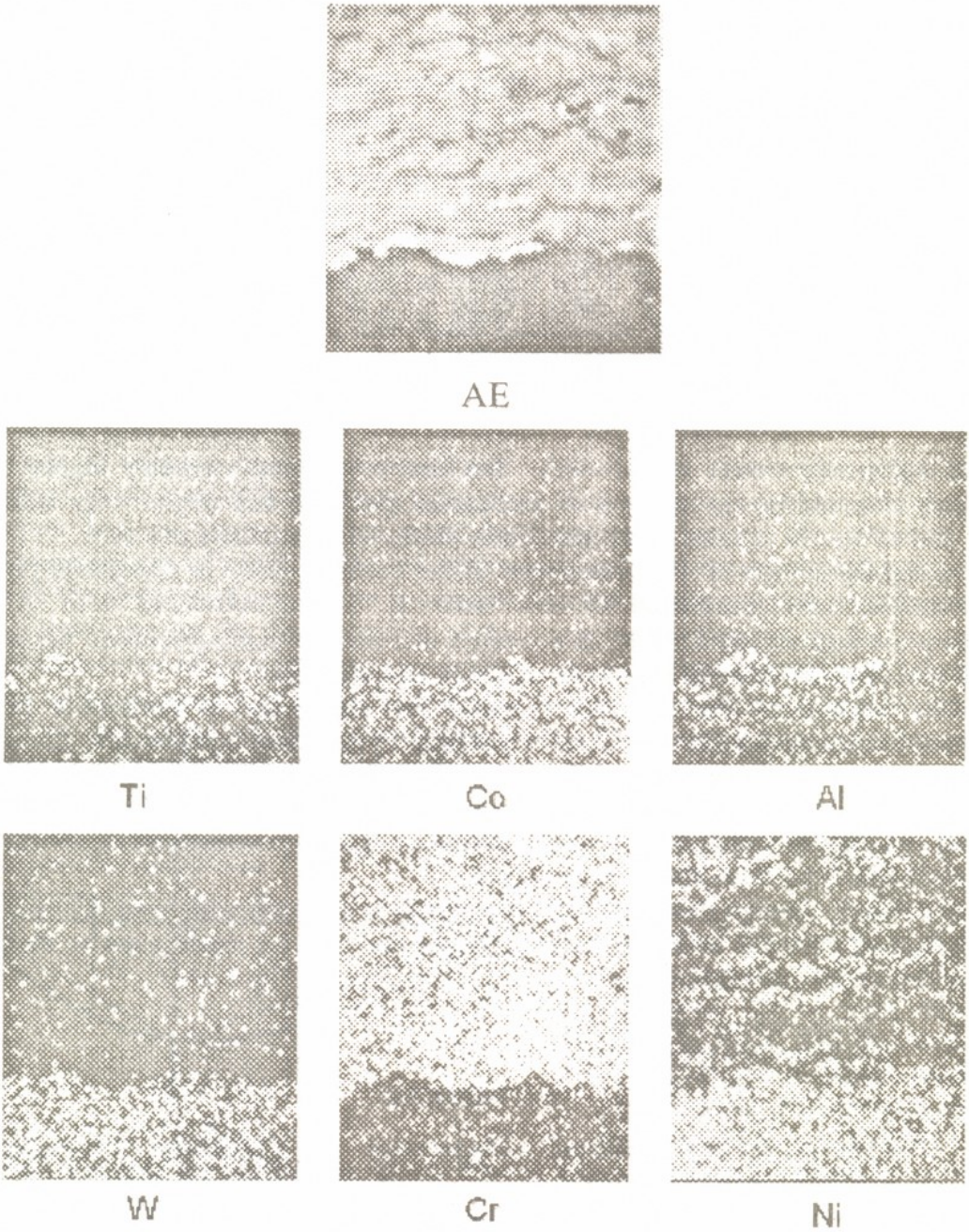

Fig. 6. Images of detonation coating of mechanical mixture of powders $NiCr+Cr_3C_2$ in absorbed electrons (AE) and characteristic roentgen rays.

of nickel-chromium and chromium carbide. Comparison of microstructures shows that the coatings of composite powders are more dense with lower porosity. Alongside with it, coatings made of mechanical mixture are characterized by lamellar structure and uneven distribution of carbide particles and pores. The same is verified by the results of microroentgenospectral analysis, which was conducted in characteristic roentgen rays. Spectral analysis was made of the main elements of the sprayed powders and metals of backing: Ni, Cr, Co, Ti, Al, W. Images of coatings in absorbed electrons (AE) and characteristic rays are given in the Figs. 3-6.

The analysis revealed uniform even distribution of chromium and nickel in metal backing. Partial transition of components of heat-stable alloy of backing – titanium, aluminum, wolfram and cobalt in the sprayed layers was also observed.

Mechanical properties of coatings were studied by experiments for strength of adhesion to direct pull [1]. Comparison of the obtained results show that σ_{ad} for the samples with plasma coatings of mechanical mixtures is equal to 8.0 MPa, while adhesion - bonding strength of the samples sprayed with composite powders is almost twice higher and makes it 15.5 MPa. The data of σ_{ad} are markedly higher for the samples obtained by the method of detonation spraying, and respectively amount to 22.5 and 49.0 MPa in case of mechanical mixtures and composite powders.

For the estimation of wear-resistance of the coatings made of composite powders, experiments were conducted on the wear at fretting-corrosion, both at room temperature and at 900°C [2,3]. It appeared that plasma coatings reduce the wear in ~ 1.5 and detonation in ~ 2.0 at room and high temperatures.

Thus, studies of the coatings revealed the advantage of composite powders compared with mechanical mixtures of powders of the same composition. Lamination of the coating structures of mechanical mixtures is apparently connected with the lamination in gas flow due to non-equal speed of particles motion differing in specific gravity. Alongside with it metal backing of the composite powders staves off reflection of carbide particles from the sprayed surface.

As a result, more perfect structure of coatings is obtained with even distribution of strengthening particles without internal tensions that may be conditioned by difference in coefficients of thermal expansion.

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T.Javakhishvili

Parameters of Oscillating Aerial Rope-Way Carrier Ropes and Dynamic Influence on the Draught Rope

Presented by Academician A.Dzidziguri, May 10, 1996

ABSTRACT. **Oscillating aerial rope-way carrier ropes with the stretching load is presented by the equivalent spring. While calculating bringing rigidity and mass of a rope the load magnitude as well as the place of its activity are taken into account. The bringing rigidity and mass calculation formula and draught rope generalized reaction calculation methodology during the car oscillation are proposed.**

In case of vertical transverse oscillation of the aerial rope-way carrier ropes longitudinal oscillation of hanged car takes place. Carrier rope, car cabin and draught rope create one oscillating system with distributed parameters. Its processes are characterized by lots of peculiarities and their investigation is extremely difficult.

One of the displays of oscillation is presented by the dynamic action on the draught rope. It creates danger for the reliability of the draught rope fixation on the car cabin during the intensive movements and especially while using large capacity car cabins. It is known, to be extremely of a high importance for the movements security provision. Such action can cause another undesirable event, for example, vertical transverse oscillation of a draught rope, its clash with a carrier rope and their swamp.

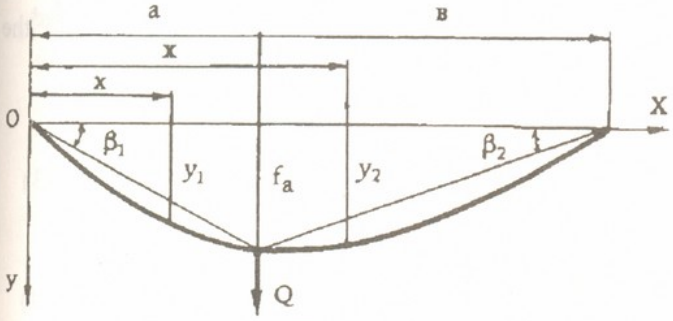

Fig. 1.

For approximate estimation of a carrier rope and car cabin dynamic action on the draught rope it is enough to present the element of the oscillating system – a carrier rope by the equivalent spring with hanged bringing mass and to consider only vibration of cabin's suspend point instead of the whole rope-way oscillation. L.Kab and V.Reckach consider the oscillating carrier rope in this way[1]. In all cases for a rope-way mass bringing coefficient they offer the same value, $k = 0{,}333$ and $k = 0{,}5$ correspondingly. The investigations presented in [2] also give the possibilities to evaluate above mentioned parameters taking into account the load factor when it acts in the middle of the span. But, as it will be shown below, the equivalent spring rigidity and rope-way bringing mass depend not only on the load value but also on its location in the span.

Let's consider horizontal span of pendulum rope-way with the length l. Assume that the stretching load of the carrier rope is located on a distance a from the fulcrum (Fig.1). Carrier rope's ordinates in the left $0 \le x \le a$ and right $a \le x \le l$ branches are

$$y_1 = \frac{f_a}{\varepsilon ab}[(\varepsilon b + \gamma_1 a)x - \gamma_1 x^2];$$

$$y_2 = \frac{f_a}{\varepsilon ab}\{al(\varepsilon - \gamma_2) + [\gamma_2(a + l) - a\varepsilon]x - \gamma_2 x^2\},$$

correspondingly where

$f_a = \frac{aqb}{2H}$ presents the rope sag at the point;

q - is a weight of rope longitudinal meter;

H - is rope tension;

$\varepsilon = \frac{ql + 2Q}{ql}$ - load factor;

Q - condensed load;

$$\gamma_1 = \frac{1}{\cos\beta_1}; \qquad \operatorname{tg}\beta_1 = \frac{f_a}{a};$$

$$\gamma_2 = \frac{1}{\cos\beta_2}; \qquad \operatorname{tg}\beta_2 = \frac{f_a}{b}.$$

Let's express rope sag f_a with the maximum sag f which is derived in the middle of the span while the load action in this point is $f_a = \frac{4ab}{l^2}f$. Besides, let's assume that during the vertical transverse oscillation the additional rope sag on its length varies according to the same rule as while the static action of Q force. In this case we can write

$$y_1 = \frac{4(f + y)}{\varepsilon l^2}[(\varepsilon b + \gamma_1 a)x - \gamma_1 x^2]; \tag{1}$$

$$y_2 = \frac{4(f + y)}{\varepsilon l^2}\{al(\varepsilon - \gamma_2) + [\gamma_2(a + l) - a\varepsilon]x - \gamma_2 x^2\}, \tag{2}$$

where y is the additional changeable rope sag in the middle of the span while the oscillation.

Approximate lengths of rope-way branches are calculating as follows

$$S_1 = \int_0^a \left[1 + \frac{1}{2}(y_1')^2\right]dx = \frac{l}{2} + \frac{8a}{3\varepsilon^2 l^4}(3\varepsilon^2 b^2 + \gamma_1^2 a^2)(f + y)^2; \tag{3}$$

$$S_2 = \int_a^l \left[1 + \frac{1}{2}(y_2')^2\right]dx = \frac{l}{2} + \frac{8b}{3\varepsilon^2 l^4}(3\varepsilon^2 a^2 + \gamma_2^2 b^2)(f + y)^2. \tag{4}$$

The whole length

$$S = S_1 + S_2 = l + \frac{8}{3\varepsilon^2 l^4}(3\varepsilon^2 abl + \gamma_1^2 a^3 + \gamma_2^2 b^3)(f + y)^2. \tag{5}$$

Rope extension while oscillation is $\Delta S = S - S_0$, where S_0 is the initial length of a rope when $y = 0$.

Due to stall values of carrier ropes sag tension alteration can be ignored and potential energy increase can be calculated according to the formula [2,3]

$$\Pi_{\text{rope}} = H\Delta S = \frac{cy^2}{2}, \tag{6}$$

where $c = \frac{16H}{3\varepsilon^2 l^4}(3\varepsilon^2 abl + \gamma_1^2 a^3 + \gamma_2^2 b^3)$ - is a loaded carrier rope bringing rigidity.

Kinetic energies of the first and second branches of oscillating rope-way can be calculated correspondingly

$$T_1 = \frac{q}{2g}\int_0^a \dot{y}_1^2 dx = \frac{4qa^3\dot{y}^2}{15g\varepsilon^2 l^4}(10\varepsilon^2 b^2 + 5\varepsilon\gamma_1 ab + \gamma_1^2 a^2);$$

$$T_2 = \frac{q}{2g}\int_a^l \dot{y}_2^2 dx = \frac{4qb^3\dot{y}^2}{15g\varepsilon^2 l^4}(10\varepsilon^2 a^2 + 5\varepsilon\gamma_2 ab + \gamma_2^2 b^2),$$

where g is an acceleration of gravity.

Complete kinetic energy of a loaded oscillating rope-way is

$$T_{\text{rope}} = T_1 + T_2 = k\frac{m\dot{y}^2}{2}, \tag{7}$$

where $m = \frac{ql}{g}$ is a rope mass;

$k = \frac{8\left[10\varepsilon^2 a^2 b^2 l + 5\varepsilon ab(\gamma_1 a^3 + \gamma_2 b^3) + \gamma_1^2 a^5 + \gamma_2^2 b^5\right]}{15\varepsilon^2 l^5}$ - is a bringing coefficient of rope mass.

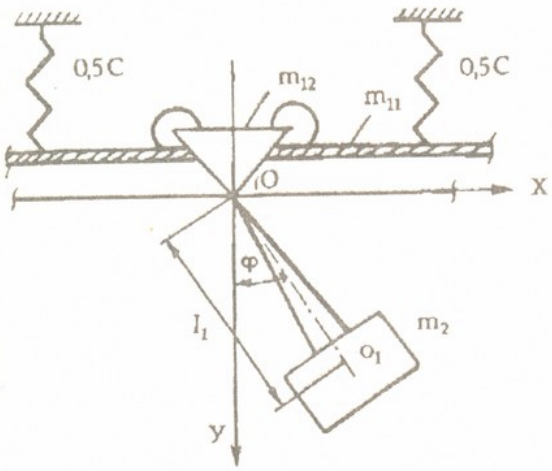

Fig. 2.

So, carrier rope can be presented by a spring with the equivalent constant rigidity c located in the middle of a rope where the part of rope-way mass $m_{11} = k \cdot m$ is hanged (bringing mass). Bringing rigidity and bringing coefficient of mass are constant values for concrete cases. Generally their meaning depends on a load value and its action place.

If we assume that draught rope tension rigidity is large and potential energy change during the car cabin suspend point vibration is negligible, system's kinetic and potential energies can be expressed by the following formula (Fig.2)

$$T = \frac{m_1 + m_2}{2}\dot{y}^2 + \frac{m_2}{2}(l_1^2 + \rho^2)\dot{\varphi}^2 - m_2 l_1 \dot{y}\,\dot{\varphi}\sin\varphi; \tag{8}$$

$$\Pi = \frac{cy^2}{2} - m_2 g l_1 \cos\varphi, \tag{9}$$

where $m_1 = m_{11} + m_{12}$;

m_{12} - is the sum of a car truck mass and draught rope partial mass;

m_2 - mass of car cabin and hanger;

l_1 - distance between suspend point of car and center of cabin and hanger masses;

ρ - radius of cabin (together with hanger) inertia concerning to the axis parallel to the suspend axis which passes through the centers of masses;

φ - is a cabin deflection from vertical.

In the case of incomplete oscillation energy dispersion system's free movement equations will take form

$$\begin{aligned}(m_1+m_2)\ddot{y}+b_1\dot{y}-m_2l_1(\ddot{\varphi}\sin\varphi+\dot{\varphi}^2\cos\varphi)+cy=0;\\ m_2(l_1^2+\rho^2)\ddot{\varphi}+b_2\dot{\varphi}-m_2l_1(\ddot{y}-g)\sin\varphi=0,\end{aligned} \tag{10}$$

where b_1 and b_2 are constant positive coefficients.

Let us define draught rope reaction, i.e. dynamic action of an oscillation on the draught rope, as a generalized reaction of a rejected link[4]. Let's consider the same system where a link realized by a draught rope is rejected. Such system has already got three freedom degrees; let's mark a new generalized coordinate with x. Kinetic energy of a system with the free freedom degrees is

$$T'=\frac{m_{12}+m_2}{2}\dot{x}^2+\frac{m_1+m_2}{2}\dot{y}^2+\frac{m_2}{2}(l_1^2+\rho^2)\dot{\varphi}^2-m_2l_1(\dot{x}\dot{\varphi}\cos\varphi-\dot{y}\dot{\varphi}\sin\varphi). \tag{11}$$

Virtual work equals

$$\delta A=[(m_1+m_2)g-cy]\delta y-m_2gl_1\sin\varphi\delta\varphi. \tag{12}$$

Correspondingly the generalized forces are

$$Q_x=0;\ Q_y=(m_1+m_2)g-cy;\ Q_\varphi=-m_2gl_1\sin\varphi$$

and the generalized reaction of draught rope is

$$\lambda_x=\frac{d}{dt}\frac{\partial T'}{\partial\dot{x}}-\frac{\partial T'}{\partial x}-Q_x=m_2l_1(\ddot{\varphi}\cos\varphi-\dot{\varphi}^2\sin\varphi). \tag{13}$$

After solution of (13) it is assumed that .

While the determination of λ_x by the (13) the values of φ, $\dot{\varphi}$ and $\ddot{\varphi}$ parameters are calculated on the basis of (10) equation system.

From the above results it is evident that connections among partial systems are nonlinear. Due to this in the case of small oscillations carrier ropes and car cabin oscillations are independent from each other and do not cause dynamic action on the draught rope. But quite often mentioned oscillations can't be considered as small, that is why in order to investigate interdependence between y and φ systems and dynamic action on a draught rope it is necessary to use nonlinear (10) and (13) equations.

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D.Namgaladze, W.Nanitashvili, A.Gogoladze

Definition of Parameters of Non-Stationary Pressure-Flow Movement by the Method of Stochastic Approximation

Presented by Academician O.Natishvili, May 17, 1996

ABSTRACT. **The work is devoted to the solution of inverse problems under the conditions of unstable head movement parameters: hydraulic resistance coefficient, shock wave propagation velocity in the given liquid and inner diameter of the pipeline.**

The method of stochastic approximation (method of Robbins-Monro) is used in this work.

The most important problem for solving operational control problems for industrial pipelines is the definition of parameters of non-stationary movement of liquid and hydraulic resistance coefficient according to the results of technological measurement in the process of pipelines operation. In industrial conditions all measurements are performed with a certain error. Thus meaning of these parameters defined by experimental data contain considerable errors.

Let's consider the possibility of defining these parameters by the method of stochastic approximation [1]. Where the procedure of calculation will be considered as the method of successive approximations with the imposed accidental component free of any accidental error.

Dislike [2] where analogous task is solved ignoring convecting members $v\frac{\partial v}{\partial x}$ and $v\frac{\partial P}{\partial x}$, we consider these members in the equation of movement:

$$\begin{cases} \frac{\partial P}{\partial x} + \rho v \frac{\partial v}{\partial x} + \rho \frac{\partial v}{\partial t} + 2K\rho v = 0 \\ \frac{\partial P}{\partial t} + c^2 \rho \frac{\partial v}{\partial x} + v \frac{\partial P}{\partial x} = 0 \end{cases} \tag{1}$$

Writing down Equation (1) in differential form:

$$\begin{cases} \frac{P_{i+1,j} - P_{i-1,j}}{2\Delta x} + \rho v_{i,j} \frac{v_{i+1,j} - v_{i-1,j}}{2\Delta x} + \\ + \rho \frac{v_{i,j+1} - v_{i,j-1}}{2\Delta t} + X_1 \rho v_{i,j} = 0 \\ \frac{P_{i,j+1} - P_{i,j-1}}{2\Delta t} + X_2 \rho \frac{v_{i+1,j} - v_{i-1,j}}{2\Delta x} + \\ + v_{1,j} \frac{P_{i+1,j} - P_{i-1,j}}{2\Delta x} = 0 \end{cases} \tag{2}$$

or

$$\left.\begin{aligned} A_{i,j} + B_{1,j} X_1 = 0 \\ C_{i,j} + F_{i,j} X_2 = 0 \end{aligned}\right\}, \tag{3}$$

where

$$\left\{\begin{aligned} A_{i,j} &= \frac{P_{i+1,j} + P_{i-1,j}}{2\Delta x} + \rho v_{i,j} \frac{v_{i+1,j} - v_{i-1,j}}{2\Delta x} + \\ &\quad + \rho \frac{v_{i,j+1} - v_{i,j-1}}{2\Delta t} \\ B_{i,j} &= \rho v_{i,j} \\ C_{i,j} &= \frac{P_{i,j+1} - P_{i,j-1}}{2\Delta t} + v_{i,j} \frac{P_{i+1,j} - P_{i-1,j}}{2\Delta x} \\ F_{i,j} &= \rho \frac{v_{i+1,j} - v_{i-1,j}}{2\Delta x} \\ X_1 &= 2K \\ X_2 &= c^2 \end{aligned}\right. \tag{4}$$

Thus, the task comes to definition of X_1, X_2 according to the results of measuring pressure and velocity along the length of pipeline at different time moments. For these kinds of tasks the procedure of stochastic approximation is reduced to Recurrent Procedure of Robbins-Monro [1]:

$$\overline{X}(T+1) = \overline{X}(T) - \gamma(T) R^2[\overline{X}(T)], \tag{5}$$

where $\overline{X}(T)$ - vector with coordinates X_1 and X_2,

T - step number,

$\gamma(T)$ - number row corresponding to the conditions:

$$\sum_{T=1}^{\infty} \gamma(T) = \infty, \qquad \sum_{T=1}^{\infty} [\gamma(T)]^2 < \infty, \tag{6}$$

where $R[X(T)]$ - value of certain monotonously reducing vector of X function.

Consider the following as the criteria of optimal function loss:

$$\left.\begin{aligned} I_1 &= \sum_{i,j} \left(A_{i,j} + B_{i,j} X_1 \right)^2 \\ I_2 &= \sum_{i,j} \left(C_{i,j} + F_{i,j} X_2 \right)^2 \end{aligned}\right\} \tag{7}$$

Let

$$\left.\begin{aligned} P_{i,j} &= P_{i,j}^T + \varepsilon_{i,j} \\ v_{i,j} &= v_{i,j}^T + o_{i,j} \end{aligned}\right\} \tag{8}$$

where $P_{i,j}^T$ and $v_{i,j}^T$ - unknown real meanings of pressure and velocity at i point per time moment j, P_{ij} and V_{ij} - measured meanings of pressure and velocity, ε_{ij} and o_{ij} - accidental errors.

Supposing for the different x_i points and time moments t_j errors are independent accidental values with zero mathematic expectance and evenly limited to a certain extend of central moments.

[2] shows that X_1 and X_2 values from equation (1) where precise p and v changed to observed values are displaced. Hence equation (1) should be considered as stochastic towards X_1 and X_2 parameters. That is why for receipt asymptotic nondisplaced value stochastic approximation method is applied in particular method of Robbins-Monro.

Thus we have:

$$\begin{cases} A_{i,j} = A^T_{i,j} + E_1, \quad B_{i,j} = B^T_{i,j} + E_2, \\ C_{i,j} = C^T_{i,j} + E_3, \quad F_{i,j} = F^T_{i,j} + E_4, \end{cases} \tag{9}$$

where

$$\begin{cases} A^T_{i,j} = \dfrac{P^T_{i+1,j} - P^T_{i-1,j}}{2\Delta x} + \rho v^T_{i,j} \dfrac{v^T_{i+1,j} - v^T_{i-1,j}}{2\Delta x} + \\ \qquad + \rho \dfrac{v^T_{i,j+1} - v^T_{i,j-1}}{2\Delta t} \\ B^T_{i,j} = \rho v^T_{i,j} \\ C^T_{i,j} = \dfrac{P^T_{i,j+1} - P^T_{i,j-1}}{2\Delta t} + v^T_{i,j} \dfrac{P^T_{i+1,j} - P^T_{i-1,j}}{2\Delta x} \\ F^T_{i,j} = \rho \dfrac{v^T_{i+1,j} - v^T_{i-1,j}}{2\Delta x} \end{cases} \tag{10}$$

$$\begin{cases} E_1 = \dfrac{\varepsilon_{i+1,j} - \varepsilon_{i-1,j}}{2\Delta x} + \rho v^T_{i,j} \dfrac{o_{i+1,j} - o_{i-1,j}}{2\Delta x} + \\ \quad + \rho o_{i,j} \dfrac{v^T_{i+1,j} - v^T_{i-1,j}}{2\Delta x} + \rho \dfrac{o_{i,j+1} - o_{i,j-1}}{2\Delta t} \\ E_2 = \rho o_{i,j} \\ E_3 = \dfrac{\varepsilon_{i,j+1} - \varepsilon_{i,j-1}}{2\Delta t} + v^T_{i,j} \dfrac{\varepsilon_{i+1,j} - \varepsilon_{i-1,j}}{2\Delta x} + \\ \qquad + o_{i,j} \dfrac{P^T_{i+1,j} - P^T_{i-1,j}}{2\Delta x} \\ E_4 = \rho \dfrac{o_{i+1,j} - o_{i-1,j}}{2\Delta x} \end{cases} \tag{11}$$

For minimal function loss determination $\partial I_1/\partial X_1$ and $\partial I_2/\partial X_2$ derivatives can be found:

$$\frac{\partial I_1}{\partial X_1} = 2\sum_{i,j} B_{i,j}(A_{i,j} + B_{i,j}X_1) = 2\sum_{i,j}(B^T_{i,j} + E_2)\left[\left(A^T_{i,j} + E_1\right) + \left(B^T_{i,j} + E_2\right)X_1\right] = \tag{12}$$

$$= 2\sum_{i,j}\left[A^T_{i,j}B^T_{i,j} + E_2 A^T_{i,j} + E_1 B^T_{i,j} + E_1 E_2 + (B^T_{i,j})^2 X_1 + 2B^T_{i,j}E_2 X_1 + E_2^2 X_1\right],$$

$$\frac{\partial I_1}{\partial X_2}=2\sum_{i,j}F_{i,j}(C_{i,j}+F_{i,j}X_2)=2\sum_{i,j}(F_{i,j}^T+E_4)\left[(C_{i,j}^T+E_3)+(F_{i,j}^T+E_4)X_2\right]= \quad (13)$$

$$=2\sum_{i,j}\left[F_{i,j}^TC_{i,j}^T+E_3F_{i,j}^T+E_4C_{i,j}^T+E_3E_4+(F_{i,j}^T)^2X_2+2E_4F_{i,j}^TX_2+E_4^2X_2\right].$$

Let's make averaging taking into consideration that mathematic expectance is equal to:

$$\begin{cases} M\{\varepsilon\}=M\{0\}=0 \\ M\{E_1\}=M\{E_2\}=M\{E_3\}=M\{E_4\}=0 \\ M\{\varepsilon_{i,j}^2\}=\sigma_p^2 \\ M\{o_{i,j}^2\}=\sigma_v^2 \end{cases} \quad (14)$$

as

$$\begin{cases} M\{E_1E_2\}=\dfrac{\rho^2\sigma_v^2}{2\Delta x}\left(v_{i+1,j}^T-v_{i-1,j}^T\right) \\ M\{E_2^2\}=\rho^2\sigma_v^2 \\ M\{E_3E_4\}=0 \\ M\{E_4^2\}=\dfrac{\rho^2\sigma_v^2}{2\Delta x^2} \end{cases} \quad (15)$$

so

$$\left(\frac{\partial I_1}{\partial X_1}\right)^T=2\sum_{i,j}\left[A_{i,j}^TB_{i,j}^T+\left(B_{i,j}^T\right)^2X_1\right], \quad (16)$$

$$\left(\frac{\partial I_2}{\partial X_2}\right)^T=2\sum_{i,j}\left[F_{i,j}^TC_{i,j}^T+\left(F_{i,j}^T\right)^2X_2\right], \quad (17)$$

$$\nabla\left(\frac{\partial I_1}{\partial X_1}\right)=2\rho 2\sigma_v^2X_1+2\sum_{i,j}\frac{\rho^2\sigma_v^2}{2\Delta x}\left(v_{i+1,j}^T-v_{i-1,j}^T\right), \quad (18)$$

$$\nabla\left(\frac{\partial I_2}{\partial X_2}\right)=\frac{\rho^2\sigma_v^2}{\Delta x^2} \quad (19)$$

Finally we have:

$$\begin{cases} M\left\{\dfrac{\partial I_1}{\partial X_1}\right\}=\left(\dfrac{\partial I_1}{\partial X_1}\right)^T+\nabla\left(\dfrac{\partial I_1}{\partial X_1}\right) \\ M\left\{\dfrac{\partial I_2}{\partial X_2}\right\}=\left(\dfrac{\partial I_2}{\partial X_2}\right)^T+\nabla\left(\dfrac{\partial I_2}{\partial X_2}\right) \end{cases}. \quad (20)$$

Thus as R function in the procedure of Robbins-Monro (5), is as follows:

$$\left.\begin{aligned} R(X_1) &= M\left\{\frac{\partial I_1}{\partial X_1}\right\} - \nabla\left(\frac{\partial I_1}{\partial X_1}\right) \\ R(X_2) &= M\left\{\frac{\partial I_2}{\partial X_2}\right\} - \nabla\left(\frac{\partial I_2}{\partial X_2}\right) \end{aligned}\right\}. \tag{21}$$

So convergence of Robbins-Monro procedure and definition of unknown $2K$ and C^2 coefficients can be easily made from equation (1).

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Connection Groups of Transformers

Presented by Corr. Member of the Academy Z.Kruashvili, July 1, 1996

ABSTRACT. **It is shown that standard rule of definition of groups is based on the inadequate interpretation of electromagnetic inertia law. It does not exclude errors and needs the correction. Faraday experiment and the unambiguous mathematical models of transformers are composed.**

The error is done in the theoretical argumentation of the connection groups. Experimental and calculation results do not coincide with each other [1; 2; 3; 4].

Disagreement between the theory and practice is caused by the inadequate interpretation of Lenz law.

According to Ampere two current-carrying conductors act on each other with the mechanical force. Their direction depends on the direction of currents. Lenz used this law for the moving conductors to determine experimentally the induced current direction [5].

Negative sign in Neumann formula [6]

$$e = -\frac{d\Phi}{dt} \tag{1}$$

expresses Lenz law: Ampere force between induced and inducing currents is directed opposite the transposition.

Neumann [7] generalized the induction law for the immovable contours:

$$e = \frac{\partial}{\partial t} i_1 \oint_{e_1} \oint_{e_2} \frac{(\overrightarrow{de_1}\ \overrightarrow{de_{21}})}{r} \tag{2}$$

but did not determine the direction of the rounding. Without this the formula does not express the inertia law.

Negative sign in Maxwell formula

$$rot\ \vec{E} = -\frac{\partial \vec{B}}{\partial t} \tag{3}$$

is connected with the motion direction.

In the special paragraph, in which Maxwell generalized Lenz law, mutual induction phenomenon for immovable conductors is not considered [8].

Thus, Lenz, Neumann and Maxwell consider the inertia law only for the conductors, moving through the magnetic field.

In order to compose the model of Faraday experiment Maxwell gave the ambiguous definition of the mutual inductance sign. He did not connect it with the directions of

current and represented physical processes by the "system of current equations" for the moment of switching on:

$$\left.\begin{aligned} e &= r_1 i_1 + L_1 \frac{di_1}{dt} + L_{12} \frac{di_2}{dt} \\ 0 &= r_2 i_2 + L_2 \frac{di_2}{dt} + L_{21} \frac{di_1}{dt} \end{aligned}\right\} \qquad (4)$$

Here the inertia law is expressed by d'Alembert principle, known in mechanics, which is unacceptable for the electromagnetic field. According to this system, self-induction e.m.f. and mutual induction e.m.f. are coincident in directions. This fact opposes the expressions (1) and (3), according to which the response and the response of response may have same directions. Negation of negation is positive.

The ambiguous notion of mutual inductance sign and the mechanical interpretation of the inertia law, given by Maxwell in the system (4), initiated the inadequacy, it may be said, voluntary mathematical modelling of the transformers, that has been lasting up today.

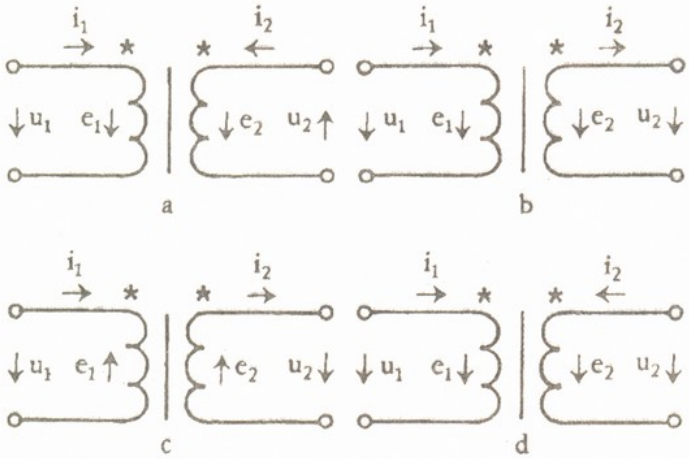

Fig.1

After Maxwell the modelling theory has been developing according to the logic: in three-phase transformer, as in Faraday experiment, mutual inductance may be as positive, as negative. Consequently, the double standard has got [1; 2; 3], according to which the one-named leads are chosen by two rules, excluding each other: According to the first rule the odd leads are assumed to be beginnings and the even leads – ends. But according to the second one – the primary winding odd leads and secondary winding even leads are taken as beginnings. The concept of the conditional positive direction of induced current has been accepted arbitrarily. The system of equations may be composed on the base of Kirchhoff law. The number of possible variants for single-phase transformer is four (Fig.1). It is considered, that all four models are adequate to the physical processes. Since the marking rules oppose each other, in the most cases the marking generally is not made. In this case mutual inductance sign essentially loses its physical sense. Sometimes it is positive, sometimes it is negative according to author's wishes. As if the problem does not exist in the modelling theory, it is clear, that the existing theory does not solve practical problems. For example: 1) the balance condition of four-winding transformer bridge [9, 10, 11]

$$\dot{A} + \dot{B} + \dot{C} = 0 \qquad (5)$$

has no physical sense, because the real parts of the items are positive numbers; 2) during the laboratory testing of active energy single-phase counter it rotates against normal direction, if the one-named leads are marked by the standard second rule; 3) while experimental determining of the three-phase transformer winding connection groups, vector diagrams of connection groups, obtained by the test and by the

theoretical calculations are not coincident. The error and the emergency switching are not excluded; 4) the composing of the system of equations for three-phase transformer by arbitrary choice is practically impossible. The variable conversion method may be used, but it doesn't give the exact image.

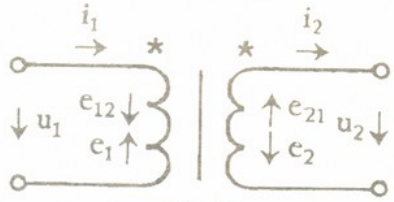

Fig.2

To prevent such difficulties discussions take place periodically. International Electrotechnical Commission discussed this question but it was not the discussion of principle. The matter was over with the simple casting a vote without change of the existing circumstance [12, 13]. The problem also was under the consideration at the Moscow Congress of the above mentioned prestige organization, but again without any results: marking double standard of one-named leads are still valid [14]. All of them ignore Lenz law and it is not correct [15].

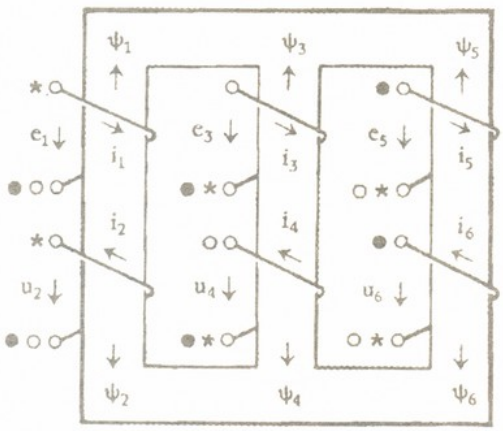

Fig.3

Let's generalize the formulae (1) and (3) of induction law for immovable contours. Define unambiguously the induced current direction in Ampere reference system on the base of Lenz law, then compose the system of equations by Kirchhoff law. With this all problems may be solved in the theory of inductive connected circuits. For this the following is necessary: 1) ignore the existing standard of marking of one-named leads, take as one-named leads with respect to which self-induction and mutual induction fluxes have the same directions of currents at the same directions of currents; 2) assume mutual induction magnetic fluxes as positive (negative), when the self-induction and mutual induction fluxes have the same (opposite) directions; 3) in Faraday experiment currents have opposite directions at the moment of switching on and the system of equations should be represented as following:

$$\left.\begin{aligned} e &= r_1 i_1 + L_1 \frac{di_1}{dt} - L_{12} \frac{di_2}{dt} \\ 0 &= r_2 i_2 + L_2 \frac{di_2}{dt} - L_{21} \frac{di_1}{dt} \end{aligned}\right\}; \qquad (6)$$

4) in Faraday experiment currents have the same directions at the moment of switching off and the system of equations should be represented as following:

$$\left.\begin{aligned} 0 &= r_1 i_1 + L_1 \frac{di_1}{dt} + L_{12} \frac{di_2}{dt} \\ 0 &= r_2 i_2 + L_2 \frac{di_2}{dt} + L_{12} \frac{di_2}{dt} \end{aligned}\right\}; \qquad (7)$$

5) processes in single-phase transformer are analogous to the processes in the first part of Faraday experiment. Therefore the model should be represented with the system (6).

Corresponding electric scheme is given in Fig.2. The primary winding is the receiver and the secondary one is the source;

6) in the three-phase transformer primary and secondary currents have the opposite directions (Fig.3). The adequate model has the following form:

$$\left.\begin{aligned}
e_1 &= r_2 i_1 + L_1\frac{di_1}{dt} - L_{12}\frac{di_2}{dt} - L_{13}\frac{di_3}{dt} + L_{14}\frac{di_4}{dt} - L_{15}\frac{di_5}{dt} + L_{16}\frac{di_6}{dt}\\
0 &= r_2 i_2 - L_{21}\frac{di_1}{dt} + L_2\frac{di_2}{dt} + L_{23}\frac{di_3}{dt} - L_{24}\frac{di_4}{dt} + L_{25}\frac{di_5}{dt} - L_{26}\frac{di_6}{dt}\\
e_3 &= r_3 i_3 - L_{31}\frac{di_1}{dt} + L_{32}\frac{di_2}{dt} + L_3\frac{di_3}{dt} - L_{34}\frac{di_4}{dt} - L_{35}\frac{di_5}{dt} + L_{36}\frac{di_6}{dt}\\
0 &= r_4 i_4 + L_{41}\frac{di_1}{dt} + L_{42}\frac{di_2}{dt} - L_{43}\frac{di_3}{dt} + L_{44}\frac{di_4}{dt} - L_{45}\frac{di_5}{dt} - L_{46}\frac{di_6}{dt}\\
e_5 &= r_5 i_5 - L_{51}\frac{di_1}{dt} + L_{52}\frac{di_2}{dt} - L_{53}\frac{di_3}{dt} + L_{54}\frac{di_4}{dt} + L_5\frac{di_5}{dt} - L_{56}\frac{di_6}{dt}\\
0 &= r_6 i_6 + L_{61}\frac{di_1}{dt} - L_{62}\frac{di_2}{dt} + L_{63}\frac{di_3}{dt} - L_{64}\frac{di_4}{dt} - L_{65}\frac{di_5}{dt} + L_{66}\frac{di_6}{dt}
\end{aligned}\right\}. \qquad (8)$$

Magnetizing and dismagnetizing physical processes are reflected with the directions of currents and magnetic fluxes on the base of Ampere, Faraday and Lenz laws. Corresponding vector diagrams do not differ from the diagrams obtained experimentally.

We hope that International Electrotechnical Commission will consider our work as Technical Oriental Document and give us the possibility to correct the corresponding literature.

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ELECTROTECHNICS

A.Zerekidze

On Calculation Scheme of DC Machines Magnetic Circuit under Automatic Design

Presented by Academician M.Salukvadze, June 13, 1996

ABSTRACT. **Brief analysis of some works on computer calculation of direct current machines magnetic circuit has been reviewed. The method of magnetic circuit which is easily formalized and gives satisfying accuracy is suggested. For small meanings of cogged layer armature, magnetic tension is chosen from the magnetic table tabulated in computer memory. As to the high meanings of induction magnetic tension is calculated from linearized magnetization curve.**

Automatic design of DC machines put forward additional questions from the point of' view of choosing rational method of using magnetization curve data. Undoubtedly, it would be more convenient to have a simple function, which describes the magnetization curve with sufficient accuracy for practical purposes under the broad range of change of variables. An attempt to fulfill such task was put up in the work [1], but approximations of the curve suggested there are too rough.

There exists a work [2] in which piece-linear approximation for reproduction of magnetization curve is used.

Suggested in [3] parabolic polynomial approximation can give large divergence, especially under high inductions.

Different functional dependencies can be used, for instance, in description of magnetization curve the application of splines [4,5]. The splines allow to obtain the meanings of function under the wide range of argument change with high accuracy. The lack of it is that the magnetization curve of steel appears to be sticked from the parts of cubic polynoms having different variable coefficients which is rather inconvenient and needs subprogram.

The existed methods of building polymetric dependencies need in advance to set regressive equality which coefficients of definition presents the main subject of calculation.

Automatic design requires to carry out numerous calculations the number of which rises up to hundreds.

Of course, the above mentioned methods provide high accuracy but if they are used in optimization parameter design, its algorithm will be greatly complicated.

The combined method in which the part of magnetization curve up to the twisting point is put in computer memory as a table seems to be more convenient. In order to seek the other points of the curve the use of straight line equation going through two points is foreseen.

Let's regard the logic of the supplied method. After setting the geometrical measurements and sections, displacement and condensation coefficients of magnetic flux K_p and K_2 have been calculated.

$$K_{pi} = t_i \cdot l_s / (b_{zi} \cdot la \cdot K_{Fe}) \qquad i = 1, 2, 3,$$
$$K_{ri} = t_1 \cdot l_s / (b_{zi} \cdot la \cdot K_{Fe}) \qquad i = 1, 2, 3,$$

where t_i is cogged division on three sections of the cog; l_s is the length of iron armature calculation; l_a is the length of iron armature; b_{zi} is width of the cog in three sections; t_1 is a cogged division on external diameter of armature; K_{Fe} is a steel filling coefficient.

By using the meanings of the compact coefficient of magnetic flux and the induction in aerial gap B_δ, the quantities of induction in cogged sections have been defined.

$$B_{zi} = B_\delta K_{pi} \quad i = 1, 2, 3$$

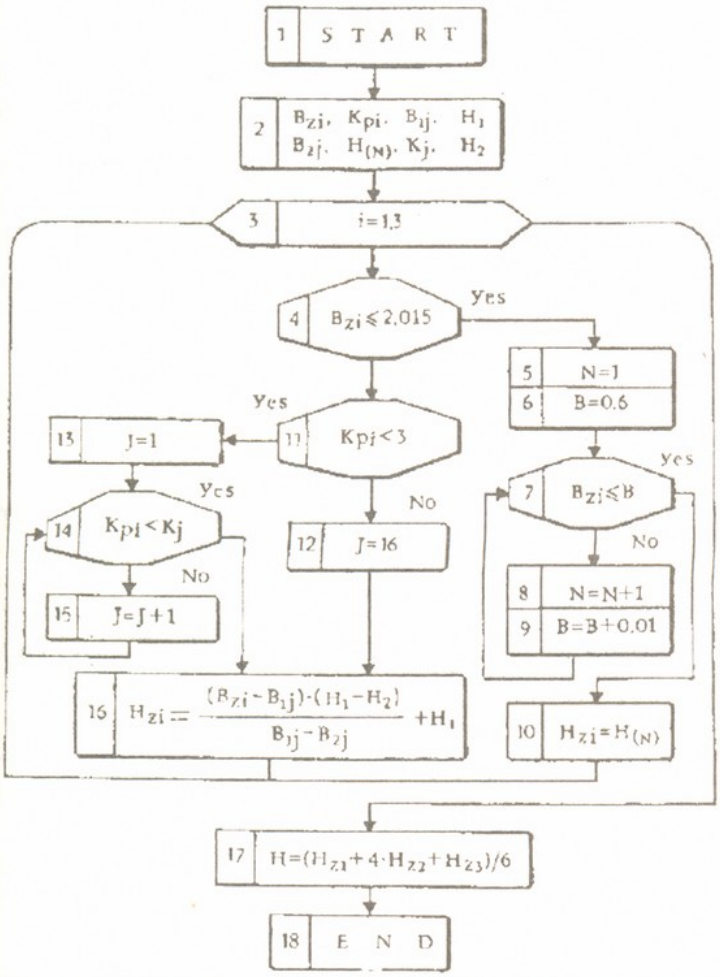

Fig. 1. Block-diagram of calculation of cogged layer armature magnetic tension.

B_{1j}, B_{2j} - The starting and final meanings of magnetic curve ordinates

H(N) - Table meanings of magnetic tensions

H_1H_2 - The starting and final meanings of magnetic curve abscissas

K_j - Coefficients of displacement the family of curves.

As it was mentioned above in computer memory there is a table of magnetization of electrotechnical steel of definite mark ($B = f(H)$) up to the bounding curve point (i.e. up to the definite quantity of induction while calculating one curve expressed in table is used).

In case if the induction is not more than 2.015 Tl (Fig.1) variable N is taken equal to 1 ($N = 1$) and then according to the table of magnetization the quantity of induction B is compared to the meaning 0.6 ($B = 0.6$). While comparing obtained by calculation the quality B_{zi} and B ($B_{zi} \le B$) to the defined tension - H_{zi} the table meaning - H is given corresponding to the meaning $B = 0.6$ or the following table meaning of B induction is given. This iterated procedure is going on until the table meaning doesn't exceed (or will be equal) the calculated meaning B_{zi}. After that the meaning H_{zi} is set by the algorithm. The above mentioned operations are fulfilled by blocks 4 - 10 (Fig. 1).

Under the meaning of induction exceeding 2.015 Tl it is necessary to take into account the displacement of magnetic flux into the groove by family of curves using coefficient of displacement. The curves of this family are performed for different meanings of coefficients and embrace the range $K_p = 0$ up to $K_p = 3$.

After defining that calculated meaning of B_{zi} is more or equal to 2.015, the comparing of corresponding to it quantity $K_p i$ with maximally envisaged quantity of displacement equal to 3 is done. When satisfying the inequality of the block 11 (Fig. 1) that curve from the family of curves is defined by which it is necessary to calculate the meaning by the equality of the straight line going through two points, i.e. blocks 13 - 16 are used (Fig. 1). Otherwise the edge curve is used from the family of magnetization curves where $Kp = 3$, block 12 (Fig. 1) and in that case block 16 is used (Fig. 1).

With the help of calculated tensions in three sections of the cog the mean value of tensions is determined by Simpson formula.

For the rest parts of magnetic circuit the calculation of magnetic tensions are performed according to simplified block-scheme without taking into account displacement and compression of magnetic flux and without Simpson formula as well.

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ELECTROTECHNICS

T.Natenadze

The Influence of Steel Property, Mass Deflaction and Magnetic Conductor Core Length on DC Traction Motor Characteristics

Presented by Academician M.Salukvadze, June 13, 1996

ABSTRACT. **In the present study we investigated the influence of electrotechnical steels composition, technological processes of cores assembling, their mass and length on output characteristics of DC traction motors. It has been shown that deflactions of core mass under constant length make less influence on change of motor characteristics than the deflactions of length under constant mass.**

The behaviour of iron alloy in respect to magnetic properties is known to be defined by the quantity and physico-chemical state of the admixtrues contained in them.

Generally the induction in strong fields is more or less reduced by the influence of foreign elements on magnetic properties of iron. However the alloying of the technical iron by silicon improves its magnetic properties. The initial and maximum penetrances increase; hysteresis losses decreas and the stability of properties essentially improves.

Power losses in ferromagnetic sections of electric machines are determined by magnetic conductor mass, magnetic induction quantity, frequency of overmagnetization, ferromagnetic mark of the material and summed up from the losses on eddy currents and hysteresis. Thus, the lowering of these losses can be reached either by the decreasing of magnetic conductor mass or by the decreasing of magnetic induction.

It should be noted that the increasing of pressure while assembling armature can increase specific losses in armature core, subjected to the process of overmagnetization during rotation.

The change of specific losses in electrotechnical steel depending on packet compression in case of sheet varnishing has been studied in monograph [1]. The same conclusion but for the sheets with thermostable isolated varnishing was made in [2].

Along with the increasing of supression the losses in steel are increasing because of the eddy currents growth proportional to the square of sheet thickness.

$$P_B = 10^{-7} \frac{1.643}{\gamma} \cdot \frac{1}{\rho} S^2 f^2 \left(\frac{B_{\max}}{10000} \right)^2 W/kg, \qquad (1)$$

where P_B - are specific losses on eddy currents;

γ - is packet density;

ρ - is specific electroresistance;

S - is sheet thickness;

f - is overmagnetization frequency;

$B_{\max}$ - is maximal induction for the given hysteresis cycle.

For the characteristics of material capacity of magnetic conductor cores it is convenient to use packetmass relation towards length. In practice this relation is defined as

$$M = Gn/lp \cdot S \cdot \gamma, \tag{2}$$

where M - is relative material capacity of magnetic conductor core;

G_n - is packet mass;

lp - is packet length under pressure;

S - is sheet area;

γ - is magnetic conductor material area.

From (2) it follows that the possibility of obtaining given mass under given core length is defined by

$$[G_n] / [lp] = S \cdot \gamma \cdot Mc,$$

where $[G_n]$, $[lp]$ - are given meanings of packet mass and length correspondingly.

Under the pressing of packets one of the discharge parameters – mass or length should become compensator of production errors. By differentiating (3) in partial derivatives and transferring from arguments augmentation to the fields of admittance we obtain for the sum of independent errors the following conditions of technologicity of magnetic conductor constructions.

1) The packet length is chosen as compensator

$$\frac{[\delta lip]}{[lp]} \geq \frac{[\delta G_n]}{[G]} + \frac{\delta S}{S} + \frac{\delta \gamma}{\gamma} + \frac{\delta M}{M}, \tag{4}$$

where δ - is stray field of corresponding parameter deflection;

$[\delta]$ - is field of deflection admittance of corresponding parameter;

2) The packet mass is taken as compensator

$$\frac{[\delta G_n]}{[G_n]} \geq \frac{[\delta lip]}{[lp]} + \frac{\delta S}{S} + \frac{\delta S}{\gamma} + \frac{\delta M}{M}. \tag{5}$$

In accordance with the above mentioned the construction magnetic conductor in which the correlation between mass and length deflections are defined (5) is considered nowadays to be technological [3].

While defining the coefficients of packets admission with steel K_{Fl} as it is adopted in ellectric machines calculations its meanings are found in

$$K_{Fl} = \frac{G_\Phi / S_H \gamma_H}{lcp}$$

G_Φ - is actual core mass;

S_H - is nominal meaning of sheets area;

γ_H - is nominal meaning of electrotechnical steel specific weight;

lcp - is actual core length;

Here the possible deflections of sheets area and specific weight of steel directly influence on the quantities of packets adminission coefficients and convertionally it can be considered that under G_Φ=const deflections of length and under lcp=const deflection of cores weight change only proportionally to oscillations of coefficient of admission.

In connection with this the given task comes to the study of influence of coefficients of admission deflections armatures cores on the motor characteristics change by

$$G_{cp}\text{=const}=G_H \quad S_H, \gamma_H, lcp\text{=var}$$

lcp=cost=l_H S_H, γ_H, G_{cp}=var

For these conditions check up calculations of characteristics of traction motors type TL - 2KI and TL - 3. In the process of operation the change of electric motors calculating parameters in connection with the change of coefficient of admission armature packets (under invariable meanings of weight or core length or other equal conditions) have been investigated.

The results of investigations testify to the fact that the deflections cover mass under constant length make less influence on characteristics change of motors than the deflections of length under constant mass.

Thus for greater stability of motors characteristics under assembling of armature packets the core length should be endured with great accuracy even on account of density.

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BOTANY

G.Gvaladze, M.Akhalkatsi

Comparative Embryology of Some Astragalus Species

Presented by Corr. Member of the Academy G.Nakhutsrishvili, May, 2, 1996.

ABSTRACT. **The embriology of two species of *Astragalus A.microcephalus* and *A.denudatus* is investigated for the first time. The general embriological characteristics and species specific peculiarities are determined for *A.caucasicus A.microcephalus* and *A.denudatus* on the basis of comparison of the obtained embryological data.**

Embryological data on *Astragalus* species are fragmentary and incomplete [1-5]. For the first time we have investigated male and female gametophites [6], embryo and endosperm development [7] of *A.caucasicus* Pall. among the species of *Astragalus* distributed in Caucasus. The embryology of two other species of *Astragalus* growing in Georgia *A. microcephalus* Willd. and *A.denudatus* Stev. is investigated in the present study. The general embryological characteristics and species specific peculiarities are determined for *A.caucasicus*, *A.microcephalus* and *A.denudatus* on the basis of comparison of the obtained embryological data.

The materials were collected near Tbilisi (*A.microcephalus*) and in Kazbegi (*A.denudatus*). The materials were fixed in formalin, glacial acetic acid, 50% alcohol (5: 5: 90) and stored in 70% ethanol. Then it was placed in clearing solution to Herr [8] and examined with a light microscope "Polyvar" (Austria, "Reichert").

According to the obtained data the embryological traits of *A.microcephalus* and *A.denudatus* are rather similar and resembling those of *A.caucasicus*. However the investigated species differ from each other by some features.

The following embryological characteristics are general for three investigated species: the formation of pollen grains in anthers is synchronous. The mature pollen grain is two-celled. The gynoecium is apocarpous, monomeric, unilocular, unicarpellate. Placentation is marginal. The newly formed ovule is anatropous. With the maturation and enlargement of the embryo sac the ovule changes its shape from anatropous to campylotropous. The ovule is bitegmic, crassinucellar. A long funiculus consists of 4-5 layer of cells. Vascular bundles reach the chalaza. The micropyle is formed only by inner integument. The innermost cell layer of the inner integument becomes a distinct layer of cells known as the integumentary tapetum. The thickness of the outer integument is much greater than that of the inner integument. The nucellar cells degenerate during the extension of the embryo sac. The mature embryo sac comes to lie adjacent to the integumentary tapetum. At this stage nucellar cells remain in the micropilar part of the ovule to form the nucellar cap and at the chalazal part occurs the postament.

Archesporium is unicellular. It forms sporogenous and primary parietal cells. The last gives rise to the cells of nucellar cap. The megaspore mother cell forms linear tetrad. The chalazal megaspore develops into an embryo sac of the Polygonum type (Fig.1A-C). The newly formed embryo sac (Fig.1B) possesses egg apparatus containing egg cell and two synergids, central cell with two polar nuclei and three antipodal cells. In the mature embryo sac (Fig.1A,C) egg apparatus has a typical structure. The polar nuclei fuse before fertilization and form a secondary nucleus. The antipodal cells are ephemeral. As the antipodals degenerate the function of transferring nutrients is assumed by the central cells [9].

The fertilization is porogamous. The pollen tube penetrates the embryo sac and discharges its content into the degenerated synergid (Fig.1D,E). At this stage the persistent synergid appears normal (Fig.1D,E) and remains unchanged until the first division of the zygote (Fig.1F). It is degenerated gradually after the division of the zygote and formation of the proembryo. The fertilization is of premitotic type (Fig.1D,E). The zygote remains in interphase for a quite a long time after the complete fusion of the pronuclei (Fig.1F).

The embryogeny conforms to the Onagrad type. The endosperm formation outstrips the embryogeny. It is of the nuclear type. The cell formation in the endosperm begins

Fig.1. A - The mature embryo sac of *A.denudatus*; B - The newly formed embryo sac of *A.denudatus*; C - The mature embryo sac of *A.microcephalus*; D-E - Fertilization in *A.microcephalus*; F - The zygote and persistent synergid in *A.microcephalus*.

after the nuclear endosperm completely occupies the cavity of the embryo sac. Different parts of the endosperm contain the cells of different structure. One should be assumed that their function are also different as it is typical for the other plant species [10, 11]. An intensified destructive processes in the whole endosperm accompanies the development of cotyledons of the embryo. In mature seed the endosperm is completely utilized by embryo and nutrients are stored only in cotyledons. The mature seed consists of the cruscent embryo and seed coat.

However the investigated species differ from each other by some features. The number of ovules in one ovary is 4-5 (*A.caucasicus, A.microcephalus*) or 6-10 (*A.denudatus*). The outer integument in *A.caucasicus* contains chloroplasts. The other two species possess whitish-transparent ovules. The character of deposition of starch grains in the embryo sac of the investigated species is one of the variable features (Fig.1A-E). The starch grains are more abundant in the embryo sacs of *A.microcephalus* and *A.denudatus* as compared with *A.caucasicus*. Starch grains are located predominantly in the micropilar part of the central cell surrounding the secondary nucleus. The amount of the starch grains is insignificant in the central, lateral and chalazal parts of the central cell (Fig.1A-C). During the fertilization the amount of starch grains decreases considerably. Some structural variability were also observed in the investigated species. Rarely antipodals namely chalazal one divide additionally and in this case the embryo sac contains four antipodals instead of three (Fig.1B). The location of the secondary nucleus in *A.microcephalus* is not strongly determined. It may be located under the egg apparatus or at the central part of central cell (Fig.1C). In *A.denudatus* the secondary nucleus is situated near the micropilar part of the central cell under the egg cell (Fig.1A,B).

A number of normal developed but unfertilized embryo sacs were observed in the investigated species. These embryo sacs are almost completely deprived of starch grains. The unfertilized embryo sacs preserve normal morphology for quite a long time and then degenerate.

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Z.Kometiani, G.Chkadua

Power Parameters of General Equation of Enzyme and Transport Velocity

Presented by Corr. Member of the Academy V.Mosidze, May 17, 1996

ABSTRACT. **General equation of the transport and enzyme velocity is considered and the physical meaning of the minimal and the maximal degrees of its numerator and denominator are deciphered in the rapid and steady-state equilibrium. The minimal degree (n) of numerator is the sum of sites for the substates and essential activators. The maximal degree of numerator is $(n + p)$, $p = l + q$, where l is number of modifiers with the partial effect. The value q depends on the complexity of molecular mechanism therefore it is defined as parameter of "complexity". $q = 0$ under the rapid equilibrium conditions. The maximal degree of the denominator is expressed by the following sum $s = n + m + l + q$, where m is the number of sites of complete inhibition (dead-end and product inhibition). The physical meaning of the power parameters of the general velocity equation requires modern interpretation in the transport case in contrast to the enzyme system and their meaning has special sense in the different transport mechanism case.**

Kinetic curves of multi-site enzyme and transport systems are characterized by the complex geometrical form that makes it difficult and often impossible to interpret their molecular mechanisms and determine kinetic parameters [1-3]. The solution of this problem in the first place depends on the determination of the number of sites and their type. In its turn it requires the numeral definition of power parameters of the velocity equation and the determination of their physical meaning. It is namely the task of the given paper.

The enzyme velocity is the function of several variables (the substrate and the modifier concentration). If we consider all the variables (with the exception of one) as the constant values then the enzyme velocity (V) dependence on any ligand concentration (x) in case of rapid and steady-state equilibrium will take the following form under the condition of non-existence of reaction products and enzyme polymerization and constant conditions of the reaction (pH, temperature, ion force, etc.):

$$V = \frac{x^n \sum_{i=0}^{p} \alpha_i x^i}{\sum_{i=0}^{s} \beta_i x^i} \qquad s = n + m + p,$$

where the positive coefficients α_i and β_i represent the function of fixed variables and individual velocity constants. n, m, p and s are the power parameters of the equation.

It is easy to determine the physical meaning of power parameters under the rapid equilibrium conditions. It is obvious that if the ligand represent the modifier, n will be

the number of the essential activator sites, p – the number of sites for modifiers (activators and inhibitors) with partial effect and s – the total number of sites. m represents accordingly number of complete inhibitor (dead-end inhibition) sites. If the ligand represents the substrate then $n = 1$ as a rule, though it will be also possible that $n > 1$. Theoretically n will be the sum of sites for substrates and essential activators in this case complete inhibitor site number (m) will represent the sum of dead-end and productive inhibition sites.

Interpretation of physical meaning of parameters under steady-state equilibrium conditions is complicated and requires special research. Let us constitute the succession of the node determinants, (D_i) with this aim using King-Altman method [4] where index i corresponds to a number of sites filled with ligand. The node determinant representing the sum of trees (products of velocity constants and ligand concentrations) is characterized by the following properties: (a) the minimal degree of the determinant is equal to quantity of sites occupied with ligand; (b) the minimal and maximal degrees of i-th determinant top corresponding ones of (i - 1)-th previous determinant by the unity. We shall get then the succession for k-number site system where the existence of the determinant with the same index is possible:

$$\begin{array}{l} D_0 = x^0[\lambda_{00} + \lambda_{01}x + \ldots + \lambda_{0q}x^q] \\ D_i = x^i[\lambda_{i0} + \lambda_{i1}x + \ldots + \lambda_{iq}x^q] \\ D_n = x^n[\lambda_{n0} + \lambda_{n1}x + \ldots + \lambda_{nq}x^q] \\ D_{n+1} = x^{n+1}[\lambda_{(n+1)0} + \lambda_{(n+1)1}x + \ldots + \lambda_{(n+1)q}x^q] \\ D_k = x^k[\lambda_{k0} + \lambda_{k1}x + \ldots + \lambda_{kq}x^q] \end{array} ,$$

where number of sites for modifiers with partial effect is denoted by l and λ_{ij} are constant coefficients. The velocity equation has the following form in accordance with the method of King-Altman:

$$V = \frac{e_0 \sum_{i=n}^{n+p} k_i D_i}{\sum_{i=0}^{k} D_i},$$

where e_0 is total enzyme concentration and k_i velocity constant. Hence the minimal degrees of numerator and denominator are correspondingly n and 0 and maximal ones $n + 1 + q$ and $k + q$. q is not equal to zero under steady-state conditions. We may define this quantity as parameter of "complexity" because its value depends on the complexity of molecular mechanism. So s and p parameters in contrast to rapid equilibrium conditions take new meaning $s = (k + q)$ and $p = (1 + q)$ while n, m and 1 parameters are left constants.

Therefore the problem of experimental definition of n, m and p parameters is arisen after clearing up of the meaning of these parameters. This problem has been partially solved. There developed sufficiently economical and precise method for the definition of n and m parameters and their errors [3,5]. The complete investigation of cation sites of NaK-ATPase system on the basis of the mentioned method with aid of the computer system is possible [6,7]. The problem is not completely solved with respect to p parameter but we can estimate it in a definite sense.

Let us consider the first derivative of $V = f(x)$ function and define the possible number of turning points (maximum and minimum):

$$\frac{dV}{dx} = \frac{x^{n-1}\sum_{j=0}^{s+p}\Psi_j x^j}{\left(\sum_{i=0}^{s}\beta_i x^j\right)^2},$$

where $\psi_i = \sum_{i=a}^{b}(n-j+2i)\,\alpha_i\beta_{j-i}$; $\begin{pmatrix} \text{if } 0 \le j \le p & \text{then } a=0 & \text{and } b=j \\ \text{if } p \le j \le s & \text{then } a=0 & \text{and } b=p \\ \text{if } s \le j \le s+p & \text{then } a=j-s & \text{and } b=p \end{pmatrix}$

Let us define the sign of ψ_i. Because $\alpha_i \ge 0$ and $\beta_i \ge 0$ we can easily suspect that $\psi_i \ge 0$ if $j \le n$ and $\psi_i < 0$ if $j \ge n + 2p$. It can be possible that ψ_i $(n < j < n+2p)$ has any sign for the rest $(2p - 1)$ coefficients. So the equation

$$\sum_{j=0}^{s+p}\Psi_j x^j = 0$$

in accordance with the Decart signs rule can have $(2p - 1)$ positive and real-valued roots or less by the even number, i.e. the number of turning points $\upsilon \le 2p - 1$. Then if we have υ turning points on the experimental curve we get the inequality $p \ge (\upsilon + 1)/2$. So we can define the lower limit of p-parameter values out of its possible ones on the basis of the geometrical form analysis of the experimental curves.

The definition of q parameter value is quite complicated. As we have mentioned above its value depends on the nature of the molecular mechanism. The different mechanisms can give the different values of q in the case of the same number of ligand binding sites. So it needs to have the additional information about the molecular mechanism. For example, if we know that modifiers connect randomly with enzyme system the relation between s and k will have the following form $s = 2^k - 1$. If we assume that n, m and p are defined it will be easy to define k and correspondingly l, q parameters:

$$k = \frac{\lg(s+1)}{\lg 2},\ q = s - k,\ l = p - q.$$

The mathematical forms of enzyme and transport velocities under the conditions of the simple mechanism are identical [8,9], but there is together with the likeness, difference in the properties, in the case of multi-site systems, which basically manifests in the interpretation of the physical meaning of the power parameters. The reason of such a difference arise from the transport own properties. We mean the substance transport as its relation with the carrier, the complex translocation in the membrane which can be accompanied by the change of affinity, the release of the substance on the other side of the membrane and the carrier translocation in the opposite direction with the possible change of affinity.

So the new term appears - transport site which can be in two conformational states. On the basis of the above discussed transport properties transport sites are only supposed and the existence of modifier ones are excluded for such transport system as mobile carrier. The transport site itself can be divided into two types by the analogy with enzyme ones: the similar to the essential activators when the occupation of the given sites is the necessary condition for the translocation of the complex and the other

- the similar to the activator site (l_α) with the partial effect when the translocation is also possible in the case of free sites. It is obvious that these sites are correspondingly transformed to the dissociation stage into sites similar to ones of product inhibition (m) and inhibition with partial effect (l_i). At the same time the equality $(n + l_\alpha) = (m + l_i)$ must be satisfied. The facilitated diffusion represents the example of the above discussed case.

Even if the certain part of the transport system is fixed in the membrane it will be possible to discuss theoretically the existence of the additional pure regulatory (modifier) sites. But we must take into account that for the transport system the existence of regulatory sites is logically inadmissible causing the dead-end inhibition. The antiport of ions with the similar affinity is the only exception. The dead-end inhibition obtains the bond possibility of the transferred ion with the counter-transportable ion site in this case.

From the above discussed examples it is obvious that certain transport mechanism requires the concrete approach which gives the possibility to establish the physical meaning of the power parameters of the general transport velocity equation in each separate case.

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BIOCHEMISTRY

R.Gakhokidze, L.Beriashvili

Metabolism of Deoxyaldonic Acids in Plants

Presented by Corr. Member of the Academy N. Nutsubidze, May 23, 1996

ABSTRACT. **It has been shown that deoxyaldonic acids formed in plants at photosynthesis, actively participate in respiration process and during their conversion different compounds are formed.**

Organic acids carry out an important role in plant turnover. In some plants deoxyaldonic acids (this structure introduces the isomers of monosugars) and their derivatives are found [1-5]. The biosynthesis and physiologic-biochemical role of these compounds are less studied. One of us studied deoxyaldonic acids formation with intramolecular change of colenhydrates [6-12] and on its base theory is made about alternative pathways of formation of organic acids in biological systems [13, 14]. It has been shown that one of deoxyaldonic acids – 2-deoxy-D-gluconic acid can be used as substrate for respiration in microorganisms [13, 15, 16].

The present work aims to study the metabolism of deoxyaldonic acids in C_3- and C_4-plants. The objects of investigation were *Beta vulgaris* (C_3-plant), kindney bean C_3-plant) and maize (C_4-plant) seedlings.

Beta vulgaris plants grown in pots were placed into plexiglass chamber with $^{14}CO_2$ (concentration 1% specific radioactivity - 80 μCi/liter). $^{14}CO_2$ was produced from $Ba^{14}CO_3$. Experiments were carried out at light, with illuminate 15-20 000 lux, temperature - 25-28°C. The duration of experiments were 1,10,30 min, 1,5 and 10 hours. Then the fixation of samples were carried out with water vapour and boiling 90% ethanol. From the ethanol fixed samples ethanolsoluble fractions were extracted with 80% ethanol four times. From these fraction sugars, organic acids and free amino acids fractions were isolated by chromatographic methods [17, 18]. From the samples fixed with water vapour, except above indicated fractions deoxyaldonic acids were also isolated by the corresponding methods [1, 2]. Experiments with 5 hour exposure were carried out in two variants. First group of plants were immediately fixed after termination of the experiment; the second group of plants were released from $^{14}CO_2$; then one part was kept at light, another in dark and deoxyaldonic acids radioactivity was measured at regular intervals.

The deoxyaldonic acids formed at photosynthesis (exposure 10 h) were isolated from *Beta vulgaris* leaves and then radioactivity was determined. To study the acids conversion, kindney bean and maise seedlings roots were put in deoxyaldonic acids solution with the same volume specific radioactivity ($2.5 \cdot 10^6$ cpm/ml). Experiments were carried out at light and dark, with exposure 10 h. The $^{14}CO_2$, emitted by conversion of deoxyaldonic acids, was bind with 20% KOH; its radioactivity was determined as $Ba^{14}CO_3$. An SL-30 scintillation counter was used for radioactivity measurements.

The results revealed that carbon of $^{14}CO_2$, assimilated by leaves of *Beta vulgaris* at photosynthesis, together with other substances, rapidly included in deoxyaldonic acids; their radioactivity constituted 15-19% of low-molecular substances radioactivity. Their radioactivity were nearly the same as that of aminoacids and di- and tricarboxylic acids radioactivity (Table 1). Thus it means that they may be immediately formed at

photosynthesis. These data are confirmed also with experiments on bean plants [7-9]. With increase of time exposure the radioactivity of these acids decreased and that of sugar fraction increased. It means that deoxyldonic acids radioactive carbon are incorporated in them. The conversion of deoxyldonic acids also conduct the data presented in the second table. As it was already mentioned one group of plants at 5 h exposure after release from $^{14}CO_2$, was kept at light and in dark. The received data showed that after definite time at photosynthesis deoxyldonic acids were formed. Radioactivity considerably decreased. After 24 h of the exposure their initial radioactivity dropped to half value, both at light and dark (Table 2). At light in comparison with dark more active expense of deoxyaldonic acids radioactive carbon of mentioned acids is observed.

Experiments with kidney bead and maize seedlings indicated that deoxyaldonic acids radioactive carbon actively incorporated in sugars, amino acids and di- and tricarboxylic acids biosynthesis. From leaves of the investigated plants significant part of their radioactive carbon was emitted as $^{14}CO_2$, especially at dark. Comparatively low radioactivity of $^{14}CO_2$, emitted at light may be due to its active refixation confirmed also by high radioactivity of sugars at light compared with dark (Table 3). Experiments on kidney bean and maize seedlings indicated that during conversion of deoxyaldonic acids together with other compounds radioactive malonic-, glicolic- and unidentified acids are also formed; these are not the Krebs cycle acids. These data indicate alternative pathways of organic acids formation in the investigatied plants. Radioactive carbon of deoxyaldonic acids transported more actively from roots to leaves of kidney bean and maize at dark, than at light. With distribution of radioactive carbon in fractions these plants are not distinguished but with emitted $^{14}CO_2$ they differ considerably. Namely radioactivity of CO_2, emitted from leaves of kidney bean at light is three times higher than with maize due to high activity photorespiration of kidney bean, as C_3-plant.

Table 1

Distribution of carbon $^{14}CO_2$, assimilated at light by leaves of *Beta vulgaris*, between the fractions of substances

Exposure, min	Total radioactivityo f fractions, 1000 cpm/g	Total radioactivity of fractions, %			
		Sugars	Aminoacids	Di- and tricarboxilic acids	Deoxyaldonic acids
1	270	41.0	18.1	21.7	19.2
10	1 980	46.3	16.7	19.4	17.6
30	3 260	49.1	14.0	19.0	17.9
60	4 610	54.6	15.2	15.1	16.1
300	12 540	61.7	13.2	10.0	15.1

Table 2

Radioactivity of deoxyaldonic acids, formed from $^{14}CO_2$, taken up by *Beta vulgaris* leaves

Experiment duration, h	Radioactivity, 1 000 cpm/g	
	Light	Dark
5 (under $^{14}CO_2$)	1 870	-
3(without $^{14}CO_2$)	1 765	1 780
6 " "	1 510	1 520
10 " "	1 310	1 330
24 " "	920	945

Table 3

Distribution of ^{14}C of deoxyaldonic acids in different fractions of kidney bean and maize seedlings; Exposure 10 h.

Variant of experiment	Plant organ	Total radioactivity of fractions, 1 000 cmp/g	Fraction % of total radioactivity			
			Sugars	Amino acids	Di- and tricarboxylic acids	CO_2
KIDNEY BEAN						
Light	root	1 430	25.8	37.4	36.8	-
	leaf	1 040	22.8	23.8	40.7	12.7
Dark	root	920	19.5	39.2	41.3	-
	leaf	1 270	8.4	18.5	38.6	34.5
MAIZE						
Light	root	1 350	24.3	36.4	39.3	-
	leaf	1 120	26.5	31.9	37.4	4.2
Dark	root	940	21.1	38.2	40.7	-
	leaf	1 410	8.7	36.4	31.3	23.6

Based on the results one can conclude that deoxyaldonic acids actively convert both in C_3- and C_4-plants.

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BIOCHEMISTRY

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The Lectin-Binding Proteins from Rat Brain Cellular Nuclei

Presented March 5, 1996

ABSTRACT. **An attempt has been made to separate the plant lectin-binding proteins soluble in phosphate buffered saline (PBS) and extractable by triton X-100 from rat brain cellular nuclei. It was determined, that the PBS soluble protein fractions (F1 - 602 kD, F2 - 104 kD, F3 - 38 kD) display lower lectin-binding activity, than proteins (F1 ≥ 660 kD, F2 - 52 kD, F3 - 18kD), extractable by triton X-100. It is notable, that these protein fractions (F1, F2, F3) have a high affinity to lectins SNA (D Lac, D Gal) and Con A and PSL (α D Man >α D Glc > D GlcNAc). The tracing relationship between the lectins RCA and SBA and protein fractions soluble in PBS and extractable by triton X-100 was observed. The affinity of PNA, WGA and STA to separate protein fractions in above mentioned conditions were not observed either.**

Glycoproteins are key compounds in the nucleo-cytoplasmic relationships and carry out a specific function in the nuclear pores action [1]. Unfortunately, these proteins (glycoproteins) have not been studied sufficiently in the nerve cells and the authors made an ettempt to investigate the plant lectin-binding proteins from nerve cells nucleus with specific affinity to terminal monosacharide of glycoconjugates.

White rats of both sexes weighing 100-120 gr were used as experimental objects. Rat brain cell nuclei were isolated by the method of Chauveau [2]. The purity of the nuclear fraction was controlled by means of a microscope. Rat brain cellular nuclear fractions soluble in phosphate buffer (PBS) and extractable by triton X-100 were prepared as described earlier [3]. Further fractionation of proteins was carried out on high pressure liquid chromatography (HPLC) with Protein PAK 300 SW column (Waters). The elution rate was 1 ml/min. The kD of proteins were established by standard proteins (Pharmacea, Sweden) (thyreoglobuline – 660 kD, ferritin – 440 kD, catalase – 232 kD, bovine albumine – 67 kD, chemotrypsinogen – 25 kD). Protein concentration was determined by the method of Lowry et al. [4].

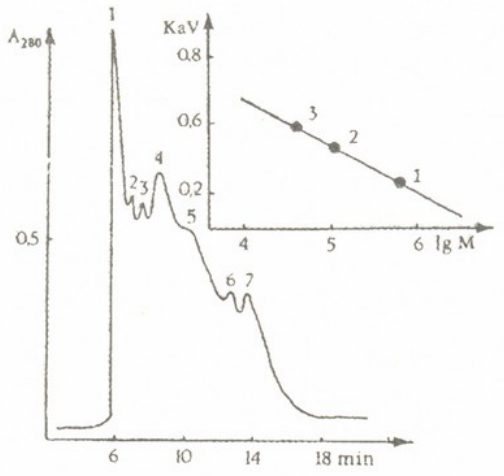

Fig. 1. HPLC gel filtration of the rat brain isolated cellular nuclei proteins soluble in PBS (PAK 300 SW). The molecular masses are established by means of using the following standard proteins (Pharmacea): Thyreoglobuline – 660 kD, ferritin – 440 kD, katalase – 232 kD, albumine – 67 kD, khemotrypsinogen – 25 kD.

Hemagglutination activity was estimated on the rabbit trypsinized erythrocytes by micro-titration on U-plates [5]. Lectin-binding ability of proteins was determined by their minimum amount inhibiting hemagglutination (the titre of lectin was 1:4), after their preliminary incubation [6]. The agglutination was carried out in 40 mM

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Table 1

Lectin-binding activity of rat brain cellular nuclei protein fractions soluble in PBS and extractable by triton X-100

№	The sources of the lectins	Lectins	The carbohydrate specificity	The protein fractions soluble in PBS and their molecular weights (kD)						The protein fractions extractable by triton X-100 and their molecular weights (kD)				
				1	2	3	4	5	6,7	1	2	3	4	5
				602	104	38	3	0,5	-	660	52	18	-	-
1			Galactosospecific											
1.	*Sambucus nigra*	SNA	D Lac, D Gal	++	++	+	+	+	-	+++	+++	+	-	-
2.	*Arachis hypogeae*	PNA	β D gal	-	-	-	-	-	-	-	-	-	-	-
3.	*Ricinus communis*	RCA	α D Gal, D GalNAc	+	-	-	-	-	-	+	+	-	-	-
4.	*Glicine max*	SBA	α D GalNAc	-	+	-	-	-	-	+	+	-	-	-
			Mannoso - (glucoso -) specific											
5.	*Canavalia ensiformis*	Con A	α D Man > α D Glc > D GlcNAc	+	++	++	+	+	-	+++	+++	++	-	-
6.	*Pisum sativum*	PSL	α D Man > α D Glc > D GlcNAc	-	+	+	+	-	-	+++	+++	-	-	-
7.	*Triticum vulgaris*	WGA	(D GlcNAc)n, n = 1, 2, 3; NANA	-	-	-	-	-	-	-	-	-	-	-
8.	*Solanum Tuberosum*	STA	(D GlcNAc)n, n = 2, 3, 4	-	-	-	-	-	-	-	-	-	-	-

potassium phosphate buffer (pH 7.4) prepared on 0,9 % NaCl. The plant lectins purchased from the firm "Diagnostikum, Lvov" were used.

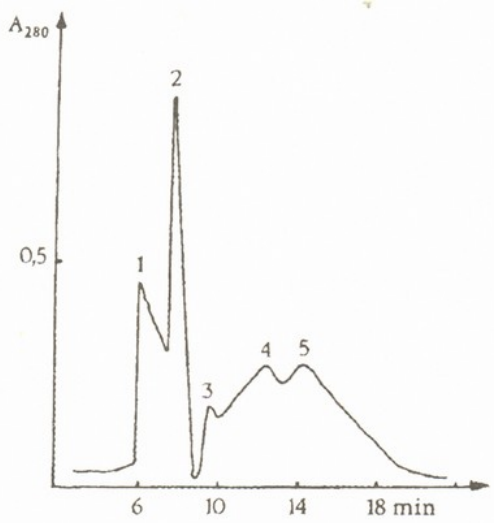

Fig. 2. HPLC gel filtration of rat brain cellular nuclei proteins extractable by triton X-100 (PAK 300 SW).

After PBS soluble rat brain cellular nuclei protein fractionation by HPLC 7 fractions were isolated (Fig. 1) and 5 fractions – from the triton X-100 extractable proteins (Fig. 2). The collected proteins in frozen condition were kept before using. All PBS soluble and triton X-100 extractable protein fractions were tested for inhibition of plant lectins activity (Table 1).

PBS soluble protein fractions, unlike the triton X-100 extractable protein fractions, display comparatively low affinity to lectins (Table 1). This was noted in the experiments with initial unfractionated proteins [3]. 3 fractions from 7, with molecular weights of F1 – 602 kD, F2 – 104 kD, F3 – 38 kD, selectively were binding with galactosospecific lectin - SNA and mannoso-(glucoso-)specific Con A. They displayed poor binding property to the lectin from *Pisum sativum* – PSL, analogous to concanavalin A, which feebly distinguishes D-glucose and D-mannose [7]. The trace relationship has been observed between the lectins RCA and SBA and with protein fractions F1 and F2. This fact indicates the presence of PBS soluble glycoproteins fractions F1, F2 and F3 following ending carbohydrates: D-Lac, D-Gal, α, D-Man, D-Glc and D-GlcNAc.

The triton X-100 extractable protein fractions F1 and F2, with the molecular weight of ≥ 660 kD and 52 kD, accordingly, differ by high affinity to the lectins SNA=Con A=PSL. These fractions display an unimportant affinity to the galactosospecific lectins RCA and SBA. Proceeding from the possibility of the column, Protein PAK 300 SW unfortunately, we were not able to fractionate the protein F1 into separate fractions and we marked it as a protein with the molecular weight of ≥ 660 kD. Protein fraction F3 with the molecular weight of 18 kD is characterized by a low affinity to lectins SNA (+) and Con A (+). Proceeding from above mentioned triton X-100 extractable protein fractions have carbohydrate residues: F1 and F2 - D-Gal, D-Lac, αD-GalNAc, αD-Man, αD-Glc and D-GlcNAc, F3 - D-Gal, D-Lac, αD-Man, αD-Glc, D-GlcNAc. Fractions F4 and F5 do not display lectin-binding property and consequently have not exerted any influence on hemagglutinating activity (Table 1).

It should be noted, that PNA, WGA and STA do not display the binding capacity to the protein fractions soluble in PBS and extractable by triton X-100. The ability of individual protein fractions to bind lectins with identical [8], and different carbohydrate specificity should be particularly emphasized.

Proceeding from the principle of lectin glycoconjugates relationship and existence of lectin-binding proteins in rat brain cellular nuclei, the identification and separation of corresponding lectins in brain nuclear fraction is in progress.

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BIOCHEMISTRY

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The Influence of CS-Gal-Lectin on the Immunoregulatory Cells Function in Various Immunopathological Models

Presented March 14, 1996.

ABSTRACT. **The influence of galactose – specific CS-Gal-lectin isolated from *Coriandrum sativum* has been studied on functional state of lymphocyte proliferation in insulindependent diabetes model. The lymphocyte migration index calculation indicates to dual action in respect to pathological state. In the model with systemic *lupus erithematosus* and Alzheimer disease the strengthenation of lymphocyte migration inhibition factor synthesis has been observed. As to acute streptococcal glomerulonephritis model the lymphocyte migration activation factor synthesis is increasing. It seems to be perspective to use CS-Gal-lectin as immunocorrector in the mentioned diseases.**

It is known that functional activity of human immune system affects pathogenesis of certain diseases. Immunodeficiency developes when the immunity is lowered and autoimmune reactions mainly appear under excessive immunoreactivity [1,2,3]. Accordingly effective determination of the indicators of human immune status is considered to be very important. Recently lectins of plant and animal origin are widely used in clinical practice for immune diagnosis [4,5,6,7]. The importance of lectin use in clinical practice derives from their stimulating effect on lymphocytes. Particularly certain plant lectins demonstrate expressed ability of influence on lymphocytes proliferation and on the synthesis of cytokines thus attracting attention to lymphocyte function regulating factors. As it is known the leucocyte migration inhibitory factor (MIF) provides leucocytes concentration in infection and inflammation site beeing promoted by Th-helpers cells stimulate the lymphocytes migration. Th- and Ts-cells are immunoregulatory subpopulations [8] and the lectins express subpopulation specificity. For example phytohemagglutinin (PHA) and Concanavalin A (Con A) are T-stimulators while Pokeweed mitogen (PWU) is Th-cells inductor and activates Th-B functional chain.

Taking into consideration all above mentioned we investigated influence of galactose-specific CS-Gal-lectin isolated from *Coriandrum sativum* [9] on lymphocyte functional activity. Human peripheral blood lymphocyte proliferation and certain cytokine - leucocytes migration inhibitory (MIF) and leucocytes migration activation (MAF) factors synthesis have been particularly studied. In addition we tried to study the influence of CS-Gal-lectin on disfunction of lymphocyte induced immune pathology. Peripheral blood of patients with Alzheimer disease, systemic *lupus erithematosus*, acute poststreptococcal glomerulonephritis (with immunocomplex factor involved) and insulindependent diabetes mellitus with gangrenous complication inducing the development of bacterial - provided T - immunodeficiency under autoimmune conditions served as a model for immune pathology.

Methods

Peripheral blood lymphocytes were separated in a ficoll - verographin gradient [10], twice washed and resuspended in RPMI - 1640 medium, with bovine embryonal serum (final concentration 10%) ("Sigma"). Final concentration of lymphocyte suspension was 1.5×10^6/ml. 150 mkl of the suspension was added to 96 - well microplates to study the CS - Gal - lectin influence on lymphocytes proliferation. In each well 1.5 mkg of the lectin was added, with no lectin in control wells. The microplates were incubated for 72 hours at 37° in 5% CO_2 - atmosphere. 24 hours before incubation stop ^3H - thymidin (1μCi) was added to all wells.After the incubation the cells were harvested on the filters (0.6 - 0.8 mm, "Flow"), washed in 0.9 NaCl solution and fixed by 96° - ethanol solution. β - radiation was detected in scintillator counter (Beckman) as the impulses quantity per 1 min.

To study the leucocytes migration inhibition reaction the leucocytes were resuspended in 100 mkl of RPMI - 1640 medium and transferred in capillaries with covered end. After centrifugation the capillaries were cut into 7-8 cm long pieces and placed in a migration chamber ("Costar"). The lectin was added in concentration of 100 mkl, the chamber was covered and incubated for 18-24 hours at 37°C. The lectin was not added in the control wells. In all wells the bovine embryonal serum was added and the whole volume was brought to 1 ml by RPMI - 1640 medium. Migration area was calculated planimetrically with the use of microphot according to the following:

$$\text{M.I.} = \frac{\text{migration area in experiments}}{\text{migration area in control}} \times 100\%,$$ where M.I. is migration index.

Results

The received results are summarized in figures I and II. It is established that CS - Gal-lectin inhibited lymphocyte proliferation in patients with insulindependent diabetes mellitus (IDDM) (Fig.I) thus expressing a suppressor ability. This effect was seen to be increased in men (Fig.I-A), suppression index being 19-20%, in women - 4.0%. According to the cytomorphological investigation such influence of the lectin on lymphocytes proliferation was not due to a cytotoxicity effect. Fig.II shows CS-Gal-lectin influence on MIF and MAF synthesis by lymphocytes. No lectin effect on leucocytes migration was detected in IDDM model (Fig.II-3): migration index corresponded to 94.7 - 99.8% both in men and women. CS - Gal - lectin induced partial inhibition of migration accordingly Th-helper stimulation in patients with Alzheimer disease (M.I.-80%) (Fig. II-1).

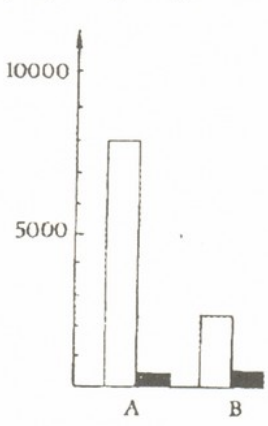

Fig. I. The influence of CS-Gal-lectin on lymphocytes proliferation in IDDM model. □ - control, ■ - in presence of lectin.

A sharp inhibition was observed in systemic *lupus erythematosus* model under lectin concentration of 150 mkg/ml (Fig.II-4): M.I. decreased to 47%. On the other hand stimulation of the supressor effect of CS-Gal-lectin was shown in acute glomerulonephritis model (Fig.II-2), M.I. increasing up to 140%. It should be noted

that commercial lectin - PWU mitogen ("Gibco") in such model activated Th-helper cells and M.I. made 63%. These results indicate increase of lymphocytes migration inhibitory factor synthesis.

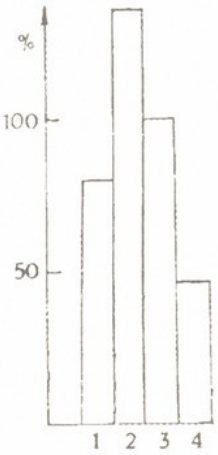

Fig.II. The influence of CS-Gal-lectin on leucocytes migration in different models of diseases. (migration index expressed in %; 1 - Alzheimer disease; 2 - acute poststreptococcal glomerulonephritis; 3 - IDDM with gangrenous complication, 4 - systemic *lupus erythematosus*.

The obtained results indicate that CS-Gal-lectin influences lymphocytes functional activity. Indeed in IDDM model with gangrenous complication the investigated lectin induced the suppression of peripheral blood lymphocytes proliferation. In patients with systemic *lupus erythematosus* the synthesis of leucocytes migration activation factor (MAF) was inhibited and helper cells were activated according to the stimulation of leucocytes migration inhibitory factor synthesis.

Taking into account the obtained results CS-Gal-lectin seems to influence specifically the immunoregulatory cells that may be used as immunocorrection mean in these disease. CS-Gal-lectin is an inductor for suppressor cells in autoimmune process development through T-immunodeficiency status although it seems to stimulate the helper chain in such classical autoimmune model as systemic *lupus erythematosus*. The studied lectin is a potential regulator with double alternative properties (suppression - helper induction) and these properties depend on the character of immunopathological processes developing in the body. From this point of view CS - Gal - lectin differs greatly from the previously studied plant lectins. The investigation in this direction should be continued.

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BIOCHEMISTRY

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Investigation of Polypeptide Contents of Plaferon LB

Presented April 18,1996

ABSTRACT. **Using the methods of the SDS-gel-electrophoresis and bidimensional thin-layer chromatography it was determined that Plaferon LB contains polypeptide fractions with molecular weights 66, 45, 36, 29, 25, 18, 14, 12, 9 kDa and free amino-acids: Ser, Thr, Gly, Pro, Ala, Phe, Val, Ile, Asp, O-Tyr.**

Test results of the several series of Plaferon LB show their qualitative identity certifing standartization of the preparation.

Plaferon LB is obtained from amniochorion of human placenta by virus induction [1,2] having antiinflaminatory [3,4], antiviral [5], antihypoxic [6] and immunomodulatory effects. A wide usage of Plaferon LB in clinical practice is based on pharmacological effects of the preparation. Particularly Plaferon LB is used for treatment and prevention of/from diseases of viral ethiology (flu, hepatitis, herpes infections, eye viral infections, etc); inflammation of mouth cavity mucosa, paradontitis, alcoholic intoxication, heart ischemic diseases, kidney and liver unsufficiency, diabetic angio and neuropathy).

Plaferon LB is a peptide preparation. A part of peptide hormones of Plaferon LB is already identified. Plaferon LB does not contain some proteins being common for placenta and foetus: α-fetoprotein, chorionic gonadotropin, trophoblastic β-globulin [2].

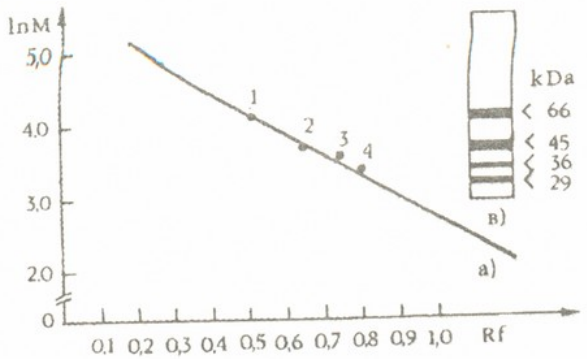

Fig. 1. a) Calibrative curve (for 5-15% gel) for determining mol. weights. 1-66 kDa, 2-45 kDa, 3-36 kDa, 4-29 kDa. b) Electrophoregram of Plaferon LB (5-15% gel).

The main purpose of our work was qualitative analysis of *polypeptide fractions and free* amino acides of Plaferon LB and standardization of the preparation production technology according to these indices. Our investigation used methods of polyacrylamide-gel electrophoresis in absence of sodium dodecylsulphate and bidimensional thin-layer chromatography.

To determine the molecular weights of polypeptide fractions acrylamide gel with concentration gradients 5-15% and 16-30% was used allowing separation of polypeptides of 5-200 kDa mol. weights. The samples were precipitated by acetone, dissolved in buffer (0.5 M Tris-HCL, PH6.8; 10% glacerol, 0.1 M EDTA 0.05% bromphenol blue) and separated by electrophoresis (strength of current 200 mA). When process was over gel was fixed (5% chloric acid, 50%

methanol) and stained (3.5% chloric acid; 0.04% Coomassie R-250). Electrophoregrams of samples were compared with electrophoregrams standard proteins collection [9]. The reagent collections of standard proteins ("Serva") with mol. weights 205, 116, 97, 66, 45, 29 kDa was used for 5-15% gel and the reagent collection of standard proteins ("Serva") with mol. weights 20, 17, 14, 12 kDa were used for 16-30% gel.

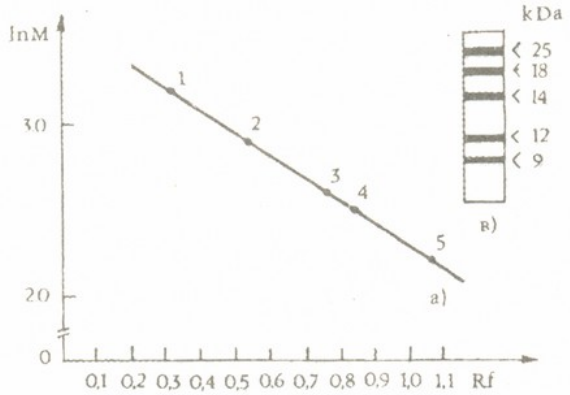

Fig. 2. a) Calibrative curve (for 16-30% gel) for determining mol. weights. 1-25 kDa, 2-18 kDa, 3-14 kDa, 4-12 kDa, 5-9 kDa; b) Electrophoregram of Plaferon LB (16-30% gel).

Free amino acids were determined by their derivatives 1-dimethylaminonaphtaline 5-Sulfhydryl (dansyl-chloride), therefore dansylation of Plaferon LB samples were used. 300 mcl of the preparation was degassed in a vacuum, the residue was disolved in 100 mcl of 0.1 $NaHCO_3$, added 100 mcl dansyl-chloride (3 mg/ml) and kept in dark for 40 min at 45^0_C [10], then it was precipitated by acetone and separated by centrifugation 4000 RDM. 5 mcl supernatant was applied on the thin layer 6X6 cm plates of silica gel. Plates were put into solution systems. Two systems were used for chromatography in the first dimension.

I system - acetone / isopropanol / ammonia (25%) 9:7:0,5

II system - acetone / isopropanol / ammonia (25%) 9:7:2

Two systems were used for chromatography in the second dimension:

I system - chloroform /benzoil alcohol/ /ethylacetate/ glacial acetic acid 6:4:5:0.2.

II system - chloroform / benzoic alcohol / ethylacetate / glacial acetic acid 7.5:6:1.5:1.5.

After chromatography the plates were developed in UV lights (wavelength 365 nm). In this section of spectrum dans-AA had yellow spot fluorescence, dansyl-OH had blue spot fluorescence.

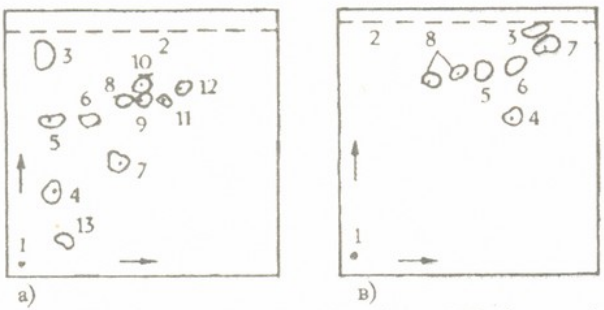

Fig. 3. Qualitative analysis of Plaferon LB free amino acids in different systems of solutions by bidimensional thin-layer chromatography: a) 1-start, 2-front, 3-dansyl-OH, 4-Ser, 5-Thr, 6-Gly, 7-Pro, 8-Ala, 9-Phe, 10-O-Tur, 11-Val, 12-Ile, 13-Asp; в) 1-start, 2-front, 3-dansyl-OH, 4-Asp, 5-Ser, 6-Gly, 7-O-Tur, 8-unidentified spots.

Chromatograms of the samples were compared with chromatograms of dansyl derivatives of standard amino acids collection ("Sevra, Feinbiochemica") [11]. Investigation of Plaferon LB series shows slight quantitative differences between series (visually according to the colouring); qualitatively they are identic.

Particularly the preparation contains polypeptide fractions of 66, 45, 36, 29, 25, 18, 14, 12, 9 kDa mol. weights (Fig.1 and Fig. 2) and free amino acids: serine, threonine, glycine, proline, phenylalanine, alanine, valine, isoleucine, asparagine, O-tyrosine (Fig. 3).

Electrophoregram of Plaferon LB was compared with electrophoregrams of other preparations obtained from amniochorion by different methods. It is found out that Plaferon LB 1 obtained by chemical method and Peptidine obtained without virus induction does not contain some polypeptide fractions characterizing Plaferon LB. Peptidine does not contain fractions of 36, 18, 12, 9 kDa mol. weights. Plaferon LB 1 does not contain fractions of 36, 29, 18, 14, 12 kDa mol. weights (Table. 1).

Table 1

Comparison of polypeptide contents of preparations from amniochorion

Plaferon LB	Peptidine	Plaferon LB - 1
mol. weight, kDa	mol. weight, kDa	mol. weight, kDa
66	66	66
45	45	45
36	–	–
29	29	–
25	25	25
18	–	–
14	14	–
12	–	–
9	–	9

Thus polypeptide contents of Plaferon LB is differ from other preparations obtained from human placenta amniochorion. But all series of Plaferon LB are qualitatively identic according to the contents of polypeptide fractions and free amino acids, that sertifies the standardization of the preparation.

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ეროვნული ბიბლიოთეკა

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BIOCHEMISTRY

T.Shavlakadze, D.Dzidziguri, P.Chelidze

The Influence of Partial Hepatectomy on Morphofunctional Activity of Nephrocyte Nuclei in White Rats

Presented by Corr. Member of the Academy G.Tumanishvili, July 25, 1996

ABSTRACT. **The influence of partial hepatectomy on transcription activity of nephrocyte nuclei in white rats has been studied. Also, morphofunctional changes of nucleoli in epitheliocytes of nephron proximal tubuli have been investigated. It has been shown that 6 hours after partial hepatectomy, transcription level in nephrocyte nuclei increases. At the same time in kidney cortex proximal tubuli the number of epitheliocytes containing active nucleoli has been demonstrated to increase. However 22 hours after the operation decrease of RNA synthesis in nephrocyte nuclei coincided with the reduction of the number of epitheliocytes containing active nucleoli in proximal tubuli. The obvious correlation between functional activity of ribosomal genes and nucleolar polymorphism has been established.**

The regulatory mechanism of gene expression in eukariotic cells is one of the most intriguing biological phenomena [1]. Regardless the fact that numerous studies have been conducted on this issue, there remain unsolved problems that are crucial to understand the entire control mechanism of the gene regulation of this cell. The study of this particular field becomes much more complex while examining higher structural levels of structural organization of chromatin [2]. Moreover thorough investigation of the mechanism of structural change in the nuclei and nucleoli during the process of activation and inactivation is required. It is well established that these changes are tightly bound to intensity of gene expression.

Several types of nucleoli have been described according to their size and structure [3 - 6]. It has been demonstrated that the existence of morphologically different types of nucleoli in tissues are highly correlated with intensity of gene expression [5, 7 - 10].

It is also documented that in tissues, where different populations of nucleoli are observed, level of RNA synthesis of ribosomal genes is correlated with nucleoli polymorphism. Specifically, studies of structural organization of nucleoli in epitheliocytes of kidney proximal tubuli have demonstrated that nephrocytes with different levels of functional activity contain different types of nucleoli.

Preceding the afore mentioned, the object of our present study was to investigate changes in nuclei resulting from the activation of transcription and to establish a correlation between these changes and nucleoli polymorphism..

Experiments were conducted with white male rats weighing 100-120 gr. The growth of the functional load of the kidney epithelial cells was achieved by partial hepatectomy conducted according to Higgins and Anderson [12]. Kidney tissue was studied at 6 and 22 hour points after operation. These intervals were chosen as in nephrocyte nuclei of white rats after unilateral nephrectomy at these particular hours activation of transcription has already been verified [11].

Nuclei were separated according to Savaue et al. [13]. RNA synthesis was measured in a purified nuclei test system by incorporation of 14C UTP labelled precursor [14].

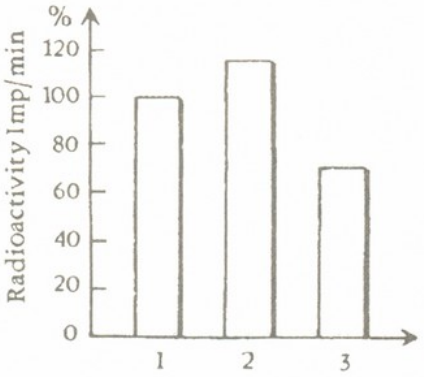

Fig.1. Intensity of RNA synthesis in isolated nuclei of nephrocytes in white rats: 1 - intact animals; 2 - six hours after the operation; 3 - twenty-two hours after the operation.

Obtained data are statistically veracious ($P<0.05$).

Radioactivity of the acid-soluble fraction was found to be increased by 15 % in nephrocyte nuclei 6 hours after the operation (Fig.1). Whereas 22 hours after the operation, the incorporation of labelled UTF into total cellular RNA was found to have decreased by 30% in comparison to the 6 hour mark. Consequently, the peak intensity of RNA synthesis in nephrocyte nuclei might be viewed as its activation against partial removal of liver tissue.

In contrast to unilateral nephrectomy partial hepatectomy resulted in a 30 % decrease in incorporation of UTP labelled precursor into total cellular RNA. This phenomenon requires further investigation and shall not be addressed in this article.

The influence of partial hepatectomy on morphofunctional activity of renal tissue has also been confirmed by the morphological analysis of epithelial cells of kidney cortex proximal tubuli.

In accordance with the morphological composition of nucleoli and the intensity of incorporation of labelled precursor, Chelidze et al. identified three main groups of nephrocytes in mice kidney cortex proximal tubuli [10].

Morphological analysis of nucleoli was conducted on semi-thin sections according to the method tested and proved effective by Chelidze et al. [10].

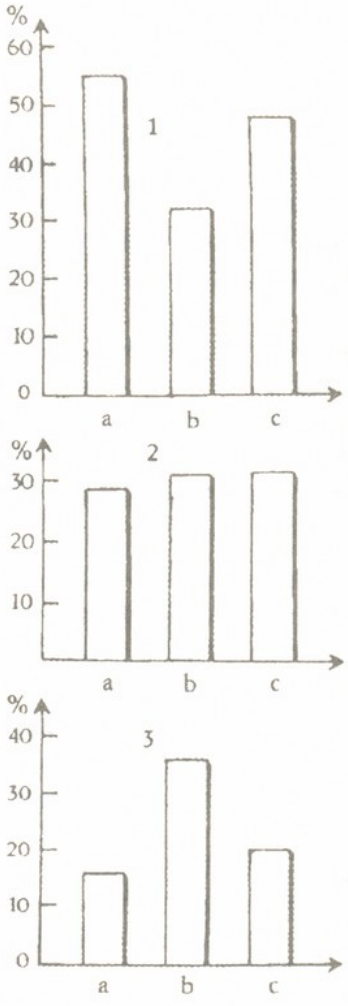

Fig.2 Volume of nephrocytes with different types of nucleoli in rat nephron proximal section: 1 - intact animals; 2 - six hours after the operation; 3 - twenty hours after the operation (a - 1st group; b - 2nd group; c - 3rd group)

In the present study, different groups of nephrocytes in rat kidney proximal tubuli were identified using the morphological criteria (nucleoli size).

The volume of the nephrocytes (1st group) containing resting ring-shaped nucleoli was 55 % in proximal tubuli of intact rats, 32 % in animals 6 hours after the operation and 48 % 22 hours after the operation (Fig. 2-a).

Regarding the nephrocytes (2nd group) with nucleoli similar in morphology to the reticular type of nucleoli, no significant difference in their number was found in any of

the experimental groups of animals (intact rats- 6 hours after operation and 22 hours after operation) (Fig. 2-b).

However, the volume of nephrocytes (3rd group) containing active reticulated nucleoli was demonstrated to be 16 % in intact rats, 36 % at 6 hours after the operation, and 20% at 22 hours after the operation (Fig. 2-c).

Therefore, in rat kidney cortex proximal tubuli 6 hours after the operation, the number of nephrocytes containing resting nucleoli (1st group) decreased by 23 %, whereas the number of nephrocytes of the 2nd and 3rd groups increased by 3 and 20% respectively.

Twenty-two hours after the operation, in comparison to the 6 hour mark, the number of the nephrocytes of the 3rd group containing active type of nucleoli decreased by 16%, the number of nephrocytes of 2nd group remained the same and the number of nephrocytes of the 1st group increased by 17%.

These results together suggest that partial hepatectomy results in activation of kidney tissue 6 hours after operation. This activation is expressed by an increase of transcriptional activity of nephrocyte nuclei and a change in the number of nephrocytes containing morphologically different types of nucleoli. Specifically, 6 hours after the operation, the number of nephrocytes with active type of nuclei increases significantly.

Twenty-two hours after the operation correlation between functional activity of nephrocyte nuclei and their morphological characteristics has also been observed. Particularly, decrease of intensity of transcriptional activity is followed by the reduction of the number of active nephrocytes in kidney proximal tubuli. Therefore, these results lead to the conclussion that functional activity of ribosomal genes is correlated with the polymorphism of nucleoli.

Additionally, stuctural and functional changes in nephrocytes caused by the increasing of functional load on kidney tissue might be viewed as the process of switching on the reserve mechanisms for tissue activation.

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MICROBIOLOGY AND VIROLOGY

T.Labadze, G.Sukhiashvili, L.Ramishvili, G.Rukhadze, Corr. Member of the Academy V.Bakhutashvili

The Isolation and Serial Passage of Cattle Coronavirus in Cell Culture *in Vitro*

Presented April 28, 1996

ABSTRACT. **The work is devoted to isolation and serial passage of cattle coronavirus in cell culture.**

This article analyses the following optimum conditions for accumulation of cattle coronavirus in cell culture: preliminary treatment of the virus inoculum with trypsin (50 mcg/ml), trypsin maintenance in the culture media (10 mcg/ml) and incubation in roller culture at a temperature of 37°C for 24-36h.

Nowadays we know at least 10 groups of viruses causing enteric disorders among human beings and animals. Among them are: rota and pararotaviruses, coronaviruses, astroviruses, parvoviruses, caliciviruses, pestiviruses. Cattle coronaviruses attract attention in terms of veterinary since the diseases provoked by them bring enormous damage to cattle-breeding industry in many countries of the world. That's why it is very important to create effective vaccines against infections caused by cattle coronavirus [1,2,3,4].

The main obstacle in studying cattle coronavirus is the difficulty of its isolation in cell culture that is of a specific prophylactic means [4].

Cell Culture. In the test we used fetal kidney seeding cell culture from cattle (MDBK). The reproduction of cell culture took place in Igla and in 199 culture media. Into cell culture we added antibiotics - penicillin (100a.u.) and streptomycin (100 mcg/ml) and 10% serum of cattle blood. Cell culture has been seeded by means of trypsin (0.25%) and versen (0.02%) mixed solutions.

Serial Passage of Cattle Coronavirus in Cell Culture. After formation of full monolayer of cells we poured out culture media and washed monolayer three times with Hanksy solution.

For the aggravation the infectivity viral suspension we treated with trypsin of 50 mcg/ml concentration and kept for the adsorption at a temperature of 37°C for an hour. Then we washed the monolayer with Hansky solution and carried in the culture media with trypsin (10 mcg/ml). We kept infected culture at a 37^0C temperature before production a CPE and then froze at – 20°C. The cultivation of virus has been taken place under roller and stationary conditions. For the detection of coronaviral antigen we used EIA [enzymo-immunoassay].

Detection of Coronaviral Antigen by Means of EIA. The maintenance of coronaviral antigen has been determined by means of EIA in 96 holed microtiter plates. We estimated results by visual observation and spectrophotometer if the length of wave reached 49 Nm. The sample scored as positive when its optical density exceeded controlling [p:N] 2.1 and much more times.

Electronic Microscopy. We carried out electronic microscopy by negative contrasting method, with JEM-1200 Ex microscopy using 2% solution of phosphorus-tungsten acid.

Fecal samples for the isolation of cattle coronavirus have been taken from calves until 3 weeks of age during enteritis explosion.

The maintenance of coronaviral antigen in fecal samples have been determined by EIA test. From 20 samples coronaviral antigen was detected only in 9 of them. By electronic microscopy in fecal samples of calves presence of typical virions peculiar to coronaviruses has been proved. Fecal samples including coronaviruses we diluted in phosphate buffer (pH 7,2-7,4) in ratio 1:4, obtained suspension was centrifuged (400g) for 15 minutes; we centrifuged oversedimentary liquid at the same regime. After that we diluted oversedimentary liquid in lgla culture media and added antibiotics-penicillin (1000 a.u.) and streptomycin (1000 mcg/ml). Fecal samples were kept at 4°C during 12 hours.

The isolation of coronavirus from the prepared samples was carried out in the same way described above. The maintenance of coronaviral antigen in cell culture was determined by EIA-test. After the first passage the accumulation of coronaviral antigen was ascertained in 5 samples. Virus replication was attended by feebly marked CPE, expressed in development of rounded cells and partial destruction of monolayer. After the fifth passage virus replication with strongly marked CPE taking place after 24-36 hours of post infection. 12 successive passages were carried out alltogether. As a result of research we also established that there are following optimum conditions for accumulation of cattle coronavirus in cell culture: preliminary treatment of the virus inoculum with trypsin (50 mcg/ml), trypsin maintenance in the culture media (10mcg/ml) and incubation at 37°C for 24-36 hours in roller culture.

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MICROBIOLOGY AND VIROLOGY

N.Kvatadze, L.Kvachadze, T.Aleksidze

Searching of Micromycetes-Cellulase Produce

Presented by Academician G.Kvesitadze, April 28, 1996

ABSTRACT. **Microorganisms of different taxonomic groups have the ability to synthesize. Among microorganisms cellulases produce micromycetes most actively. The investigation of cellulases of this group of microorganisms, showed that *Trichoderma*, *Aspergillus*, *Penicillium*, *Geotrichum*, *Fusarium*, *Sporotrichum* and many other representations of species produce various components of extracellular cellulases. Thermophilic micromycetes produceres of cellulase cause a great interest as the enzymes produced by these micromycetes are as a rule thermostable.**

The existence of microsporic fungy of cellulase producers in soil gives us possibility to choose active producers of cellulasic enzymes and in some cases to detact micromycetes grown in the extreme conditions.

In order to obtain cellulase producer mycromycetes the microorganisms were isolated from different soils of Georgia. 5 samples of soils have been studied in particular: the soil of Sabatlo grapeyeard of Dedoplis Tskaro region (deepness 0-30 cm), Dedoplis Tskaro region, Samreklo (20 cm), red soil of Natanebi citruses (0-20 cm).

The work was carried out as follows: isolation of microphlora from soil samples, obtaining of pure culture from primary seeds, culture identification, obtaining of cellulase enzymes of culture, determination of cellulasic enzyme activity.

36 strains have been isolated in all - 15 bacterial and 6 actinomycete strains.

In order to obtain pure mycromycete cultures, the primary microphlora has been isolated from soil samples. For this purpose the average sample of 10 gr. has been taken from soil sample, transferred into 100 ml flasks with sterile running water and left for 30 min. Then the mixture was shaken for 20 min and stayed for 5-10 min. for sedimentation of rough elements from the obtained suspension of the following dilution (1:100; 1:1000; 1:10000).

From each dilution 0.2 ml was transferred into Petri dish on agarized medium of beer sweet (5-5 dish) and (5-5 dish) from filter paper on Petri dish with Van-Iterson medium. 3 from 5 dish was placed in thermostate at 40°C and the two at 30°C.

Agarised beer sweet: 8% - beer sweet and 23 gr/l - agara.

Mediums were prepared on running water. Sterilization was done at 1 atm. for 40 min.

Seeds were investigated and discreted in 3-5-7 days. Later from colonies of cultures grown on disks in rough medium and filter paper, micellium samples or spores with the help of hook were transferred into the test-tube on the surphase of rough medium. Flasks were placed in thermostate at 40°C and 30°C respectively, for 7-1- days. Thus, the pure cultures of micromycetes have been obtained. Then the identification was done according to Pidoplichko (10, 11).

In oder to obtain extracellulas cellulases 10 day pure micellium culture sample or spores was inserted in the following nutrient medium (gr/1): $NaNO_3$ - 3.0; KH_2PO_4 - 2.0; $MgSO_4$ $7H_2O$ - 0.5; maise extract - 1.5%, microcrystal cellulose - 1.0%. Nutrient medium was prepared on running water at pH 4.7. 100 ml of nutrient medium was poured into 750 ml flasks and sterilized at 1 atm 40 r 40 minutes. Culture was grown on a shaker 200 turn 3 min respectively at 30^0C and 40^0C for 96 hours. After cultivation the preparation was centrifuged 4000 turn 3 min for 10 min. Cellulase activities were measured in filtrates of cultural liquid in particular Na carboxymethylcellulase cellobiase and activites on filter paper (12).

From soil of Sabatlo vineyards 6 micromycetes strains have been isolated. 3 strains appeared to be mezophylic - two *Aspergillus strains* and one *Penicillium*. 3 strains from *Aspergillus* species were thermotolerant. 4 strains have been isolated on beer sweet and 2 strains on Van-Iterson medium. All isolated micromycetes had cellulase activity. It should be mentioned that the obtained strains isolated the three components. Only one strain from *Penicillium* species had no cellobiase activity.

Nine strains had been isolated from Samreklo, Dedoplis Tskaro region - bacteria and 1 strain of actinomycete.

Representatives of species - *Aspergillus*, *Penicillium* and *Mucor* have been found in micromycetes. After investigation 4 strains were thermotolerant i.e. facultative thermophile. From 9 isolated from Dedoplis Tskaro strains 8 had the ability to synthesize all components of cellulase checked by us. The representative of *Mucor* species did not isolate cellobiose in atmosphere. All the strains have been isolated on beer medium. On Van - Iterson medium only 1 strain from *Aspergillus* sp. has been obtained having satisfied activity only by filter paper.

From red soil of Natanebi 10 strains of micromycetes, 2 bacteria, 1 - actinomycete have been isolated. From micromycetes strains have been obtained only of *Aspergillus* and *Penicillium* species. 8 from 10 strains were mezophylic, 1 - facultative thermophile and one obligatory thermophile. Four strains have been isolated on Van-Iterson medium and the other on beer sweet medium.

From *Aspergillus* 5 strains isolated all the three cellulases examined by us. Two strains had no filter paper activity and *Aspergillus fumigatus* had no Na carboxymethycellulase activity. Two strains have been isolated from *Penicillium*. One of them had Na - carboxymethylcellulase and filter paper activity and the other isolated cellobiase in a trace amount.

From the cultures obtained according to cellulase activity three strains must be distinguished from *Aspergillus species*. Two of them have been isolated in beer sweet medium and one on Van-Iterson medium.

Five micromycete strains from Natanebi soil have been isolated, two mezophylic and three thermophile. They were representatives of *Aspergillus* species. Three of them have isolated on agar medium of beer sweet and two on Van - Iterson area.

Three strains from *Aspergillus* had the ability to biosynthesize all componets of cellulase but two strains that were isolated on Van - Iterson medium did not isolate cellobiase.

From Natanebi tea plantation red soil six strains of micromycetes have been isolated. Four on agar medium of beer sweet and 2 on Van-Iterson medium did not isolate cellobiase.

From Natanebi tea plantation red soil six strains of micromycetes have been isolated: four on agar medium of sweet and 2 onVan-Iterson medium.

One representative of micromycetes was from *Penicillium* sp. and others from *Aspergillus sp.*

Four representatives of *Aspergillus sp.* had Na-carboxymethycellulase, cellobiase and filter paper activities. Only one representative of this species had no filter paper activity and the representatives of *Penicillium* did not isolate cellobiase.

Thus, from the carried out work it can be established that from 35 examined strains none had high cellulase activity. Only 7 strains had satisfity according to filter paper and one strain according to cellobiase.

Except those micromycetes isolated by us from different soils the ability of cellulase production among microscopic fungi of different species have been studied. In particular: *Mucor*, *Rhizopus*, *Aspergillus*, *Penicillium*, *Trichoderma*, *Sporotrichum*, *Chaetomium*, *Allescheria* chosen from the microorganism culture collection of the Institute of Plant Biochemistry.

It has been established that the majority of these species had the ability to biosynthesize cellulases. 12 thermophylic strains have been chosen which produce cellulases grown at 40° - 50°C. These are: *Aspergillus terreus 17 p*, *A.terreus AT - 490*, *A.versicolor*, *A.wentii*, *A.fumigatus*, *Sporotrichum pulverulentum, S. thermophile, S. praticola, Allescheria terrestris, A.terrestris. 62060, A.terrestris 62243, Chaetomium thermophile.*

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PARASITOLOGY AND HELMINTHOLOGY

Corr. Member of the Academy B.Kurashvili

The Part of Wild Birds in Spread of Infections and Invasive Diseases in Georgia

Presented June 6, 1996

ABSTRACT. **Wild birds play a considerable part as carried and disseminators of contagious diseases, parasites and vermin.**

It is known that birds make ecological contacts with representatives of various groups of disease excitants among humans and farm animals. Among excitants there are virus, spirochates, rickettsiae, fungi, chlamydiae, mycoplasma, spirelli, cocci, bacilli, bacteria, protozoa, heiminths. They cause various diseases in humans and farm animals.

A man contacts birds and is exposed to attacks of mosquitoes and mites – carriers of virus. Being the reservoir of infection excitant in the nature, birds transport the excitants from one area to the other, especially during the migration.

During the migration birds can easily spread helminths invasion from one place to another and from one type of birds to others. They play a considerable part in spread of helminths invasions.

This should be taken into consideration while forming new poultry farms and taking measures to prevent helminths among poultry.

INTRODUCTION

The aesthetic role of bird is great indeed thanks to their beautiful appearance and singing. They adorn the forests, gardens and parks, take part in plant pollination, transfer plant seeds, feed by weed seeds, harmful insects and mice rodents, reduce their number thus bringing use to agriculture. Besides, birds have been the hunting object for a very long time.

At the same time some birds spread do harm to their surroundings. They destroy crops, gardens, vineyards, useful insects, game birds fledgelings, nests, transfer some diseases both infections and invasive (parasitic).

A considerable role is assigned to birds in spreading pathogenesis of many invasive and infectious diseases which cause various diseases in humans and farm animals.

MATERIALS AND METHODS

To make clear a medical significance of wild birds, a summary table [1] made by the virologist D.Lvov, is given below (Lvov, Ilichyov, 1979).

RESULTS AND DISCUSSION

This table shows that birds get into contact with representatives of pathogenesis of various groups of human and animal diseases. They are viruses, fungi, spirochaetes, rickettsiae, chlamydiae, mycoplasma, cocci, spirelli, bacteria, bacilli. These excitants cause various diseases in humans and farm animals. Today their number is rather high. During the last decade on the territory of the former Soviet Union 9 new viruses have been found ecologically related to birds.

Table

Pathogenseses of bird diseases connected with human pathology (according to D.I.vov)

Pathogeneseses		Diseases
1		2
Protozoa	*Toxoplasma gondii* *Sarcocystic lindemanni*	Toxoplasmosis Sarcosporidosis
Bacteria	*Pseudomonas aeruginosa* *Hemophilus gallinarum* *Escherichia coli* *Salmonella* *Pasteurella multocida* *P. anatipestifer culosis* *Jersina pseudotuber* *Mycobacterium ovium* *Corine bacterium perdicum*	Pseudominiasis Infections corisa Eshericosis Salmonellosis Pasterliosis Infectious serositis (of ducks) Pseudotuberculosis Tuberculosis Ulcerous enteritis
Bacilli	*Clostridium perfrigens* *Cl. botulinum* *Brucella* *Jesinia pestis* *Francisella tularensis*	Air gangrene Botulism Brucellosis Plague Tularaemia
Spirelli	*Vibrio metschnikovi* *V. meleagridis* *V. columbae* *V. betus* *V. spp.* *Listeria monocytogenes*	Hen disease Turkey " " Pigeon " " Sparrow " " Penguin disease Listeriosis " "
Cocci	*Staphyloccus aureus* *St. pyogenes* *Streptococcus spp.*	Staphylococcosis " " Streptococcosis
Mycoplasma	*Mycoplasma gallisepticum* (*melaegridis sinoviae*)	Hen chronic disease Turkey sinusitis
Chlamydia	*Chlamydia psittaci*	Ornithosis
Rickettsia	*Rickettsia rikettsia* *R. sibirica* *Coxiella burneti*	Nettle rash Rickettsiosis caused by ticks Fever
Spirochetes	*Borrelia anserina* *Leptospira interrogans*	Spirochaetosis Leptospirosis
Fungi	*Microsporum spp.* *Trichoption spp.* *Histoplasma capsulatum* *Aspergillus fumigatus* *Candida albicans*	Herpes Herpes Histoplasmosis Aspergilliosis Candidiosis
Various viruses	Various viruses of birds, *hydrophobia* virus	Various virus diseases of poultry which are characteristic of failure of respiratory ways, alimentary canal and central nervous system

Epidemiologists are especially alarmed by the spreading of influenzal infections. According to scientists new cultures of influenzal viruses come from the seats of South - Eastern Asia and birds (migrants) are main carrier of these viruses. Virus cultures detected in rooks and gulls are identical to human influenza.

Most grave diseases which proceed similar to encephalitis and haemmorrhagic fever are caused by ARBOVIRUSES.

Arboviruses are human and animal viruses which are transferred by Arthropoda (mites, gnats, mosquitoes). They multiply actively in their organism, causing no diseases. To date more than 60 arboviruses are found in birds and their parasites and even more is expected to be detected. NATURAL SEATS are characteristic to virus infections, ecologically related to birds. These natural seats mean the following: the virus circulated in natural surroundings for a long time is transferred from bird to bird by mosquitoes and mites, or aero-dropical and alimentary ways. Man gets these viruses through the contact with birds and from mosquitoes and mites.

Arboviruses are mostly spread by migratory birds which bring them from South Africa and Africa seats (hotbeds). To date more than 10 viruses are common for the former USSR territory and the countries of South-Eastern Asia, Africa, Northern America (Voinov, 1979; Ilichyov et al., 1982).

Across the Georgian Black Sea coast there goes a big migratory way of many birds. Among them birds of pray, every autumn hundreds of thousand birds take his way to Asia and Africa countries (Mikheev, 1971).

The World Health Organization pays special attention to a problem of virus infections, ecologically related to birds. It brought the attention of virologists, parasitologists and ornithologists to a complex study of viruses.

Special programmes are being worked out and scientific research is under way. It has been found that migratory birds can have both relation and transfer virus infection.

Water and water-related birds, which live in colonies are of great ecological significance. Cultivated birds living in urbanized landscapes (pigeon, sparrow, starling, village swallow) and other wild birds are the main source of spreading invasive diseases especially helminthosis among the poultry and on the contrary invaded poultry can be the source of invasion for wild birds. They transfer helminthic invasion from one place to another and also from one species birds to another. Georgian birds (both domestic and wild) are sufficiently studied in respect to invasive diseases, especially helminthosis (Kurashvili, 1957; Kurashvili et al., 1976).

Today more than 260 species of helminthes i.e. parasitic worms have been registrated in poultry and wild birds of Georgia (Kurashvili, 1956; Kurashvili et al., 1976; Kurashvili, 1961; Group of authors, 1983; Sudarikov, 1984; Group of authors, 1987; Group of authors, 1983).

The study of helminthofauna of wild birds and poultry revealed aver 50 helminthe species which are common for poultry and wild birds. This fact can be explained by the feeding characteristics and of these birds way of life (Kurashvili, 1957; Kurashvili et al., 1976).

Diseases caused by these HELMINTHS i.e. helminthoses badly harm poultry farms and disturb reproduction of wild birds.

Here are some main helminthoses which prevale among the birds in Georgia:

Echinostomatidosis – Several species of trematode which causes this disease are widely spread in Georgia (*Echinostoma revolutum*, *Echinoparyphium recurvatum*, *Hypoderaeum conoideum*);

Prostogonimosis – the pathogene of the disease is the trematode *Prosthogonimus ovatus*, which is found in poultry (chicken, turkey and duck);

Railientinosis – the cestode *Raillietina echinobothirida* is the pathogene;

Hymenolepidosis – is caused by group species, the most pathogenic are: *Drepanidotaenia lanceolata*, *Sobolevicanthus gracilis*, *Dicranotaenia coronula*, *Fimbriaria fasciolaris*;

Syngamosis – the pathogens are: *Syngamus trachea*, *S.skrjabinomorpha*, *S.merula*;

Ascaridiosis – is caused by *Ascaridia galli*, *Ascaridia dissimilis*;

Heterakidosis – the most spread pathogenesis are: *Heterakis gallinarum* and *Ganguleteranis dispar*;

Capillariidosis – is caused by various species of Capillaria which are: *Capillaria bursata*, *C.caudinflata*, *C.obsignata*.

Syngamosis is of the most practical significance among the above-mentioned diseases. It annihilates the domestic chickens. In Georgia syngamous parasitize in rooks, starlings, thrushes, pheasants and other birds organisms. All these birds settle by poultry farms and are badly invated with syngamus. All this gives us ground to conclude that rooks, starlings, thrushes and other birds represent a strong source in spreading syngamosis. The reverse is also possible, e.g. rooks and starlings settle in colonies and groups not far from human settlements. They are usually more invated with syngamus than other birds.

While poultry (especially chickens) get invaded with syngamus by rooks and starlings both directly and through the intermediate hosts-warms (Lumbricidae).

The species of trematodes, cestodes, nematodes and warms which parasitize in wild water birds (Anatidae, Columbidae) settled near a poultry farm are registered in domestic duck (Kurashvili, 1957; Kurashvili et al., 1976).

So the spreading of echinostomatide, hymenolepide as well as polymorphism and pilicolise in poultry is promoted in the first place by the following species of water birds: A.acuta L., A.clypeata L., Anas platyrhynchos L., Aythya ferima L., Mergus L., Netta rufina Pall., Colymbus caspicus Hall., C.cristatus cristatus L and etc.

This sort of interrelation of poultry and wild birds should be taken into account when organizing poultry farms, poultry helminthosis control and preventive measures.

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ეროვნული ბიბლიოთეკა

EXPERIMENTAL MEDICINE

G.Bekaia, D.Kochiashvili

Laser Beam Treatment of Chronic Prostatites

Presented by Academician T.Ioseliani, July 18, 1996

ABSTRACT. **The patients with a severe form of chronic prostatites and those who had been treated with no success were subjected to laserotherapy with a complex of traditional methods of treatment that in 96% it gave a complete recovery. Infra-red impulse laser beam radiation was carried out by means of laser stimulator "TCP Georgia". The results were estimated by statistical treating of a special diagnostic parameters.**

In the recent years laser beam therapy has achieved wide-spread application for the treatment of inflammatory processes, postoperation wounds, ischemic disease of the heart, hypertension, osteochondrosis, arthroso-arthrites, radiculitis, neurites, and other diseases [1,2].

Involvement of laserotherapy has tangibly promoted and improved to a different extent the recovery of patients.

Convincing evidence derived from our studies shows a high efficiency of laserotherapy (its local application) when included in a complex treatment of prostatites [3].

In our earlier studies laserotherapy was applied to the patients with severe forms of chronic prostatites (38 patients) and the patients who have been treated with no success by a complex of traditional pharmacological and nonpharmacological intensive therapy (33 patients).

Infra-red impulse laser beam local radiation was carried out by means of portable laser stimulator, whose beams are deep penetrable and allow the exposure of the deep-lying visceral organs.

The stimulator has been approbated in different institutions and clinics of Tbilisi. It has been established that it has a favourable effect on the metabolism. It contributes to the enhancement of regenerative ability, activation of immunosystem, rapid extinction of inflammation and hormonal improvement.

Laserotherapy (together with the routine treatment) was carried out twice a day at 6-8 hr intervals for 10-15 minutes with a special tubs (prepared by our scheme) inserted from the surface of the perineum or the anus during 10-15 days.

The course of disease and treatment efficiency are judged by the following diagnostic parameters that have been studied in dynamics: elimination of neutrophilic leukocytes in prostatic fluid, epithelial cast off from the mucous membrane and mucous, a decrease of lecithin granules in prostatic fluid to a normal level, normalization of the sperm pH and the number of actively mobile sperm cells and lecithin granules, disappearance of the sperm neutrophilic leukocytes and sperm agglutination phenomenon.

The above-mentioned quantitative parameters were treated by Variance Statistics and the different validity was determined by Students' t-criterion.

Normalization of statistically significant indices appeared to be in accordance with the disappearance of unpleasant manifestation in the patients with chronic prostatites.

They note a complete extinction of pains in the site of urogenital system and a decrease in sexual discomfort.

Out of 71 patients being under observation with combined treatment (laserotherapy in conjunction with drug treatment) only 3 (4,2%) despite normalization of diagnostic indices, still complained of unpleasant feelings in the urogenital system.

According to data available in literature [4,5,6,7] and to our results the effectiveness of laserotherapy is well pronounced when it is combined with routine prescription in the treatment of chronic prostatites.

Constructors of laser stimulator "TCP Georgia" are A.Bobrov and Z.Razmadze.

Pulse infra-red laser stimulator has been approved and allowed for the use in medical institutions by the Ministry of Health Care of Georgia.

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EXPERIMENTAL MEDICINE

V.Mikaberidze, V.Gondzhilashvili, Z.Topuria, A.Mikaberidze

The Morphologic Aspects of Regeneration of Liver Wounds Operated by Laser Welding

Presented by Corr. Member of the Academy N.Tatishvili, August 5, 1996

ABSTRACT. **The possibilities of laser welding on liver tissues have been studied in acute experiments on rabbits. Welding of incised wounds was performed by contact and noncontact methods. Most stable suture was obtained at 1.5-3.0 watts.**

In chronic experiments the course of reparation process of the welded wounds of the liver has been studied by morphologic research and also the hemostasis, biliostasis and adhesions in peritoneal cavity have been observed.

Lasers as surgical knives are widely used in many fields of surgery. Good prospects exist in surgery for laser welding application. The use of Nd:YAG lasers in medical practice accelerated the development of this method. The laser welding has numerous advantages. The welded suture is characterized by high biological hermetic state and good course of reparative processes, at the same time the blood losses and operating period are decreased. Combined with other traditional operating methods the laser welding is successfully applied in clinical practice under operations on vessels and bowels.

Also there is a significant progress in laser liver surgery, though the problems of reliable hemostasis and biliostasis under the operation of this organ remain unsolved, especially under nontypical liver resections. The using of different hemostatical sutures causes circulatory failure in suture area and necrosis. The cutting of sutures and bad biliostasis often cause bilious peritonitis. So it's quite justified to search new and reliable closing methods for liver wounds.

We have studied the possibilities of laser welding on liver tissues in experiments on rabbits. The laparetomy under sterile condition and general shallow hexenal anesthesia, maintaining respiration were made. With Nd: YAG laser, using contact and noncontact technique, we have welded cut wounds, with 1.5 - 2 cm of length, on the front edge of the liver. During the operation the temporary hemostasis was achieved by fingers compression along the edges of the wounds. The purpose of acute experiments was to determine those optimal parameters of laser working, which provide the most strength of welded suture. It was determined by the dinamometric method, measuring a tensile strain of the suture, at which the suture was destroyed. Obtained hemostasis condition was observed. The most stable wounds were obtained at 1.5 - 3.0 watts of welding power. The optimal energies for welding were defined by 0.25-0.3 joule [1].

In chronic experiments by morphologic research on the first, third, 7-th, 14-th, 21-st and 30-th days after operation, we have studied course of reparation process of the welded wounds of the liver and also observed hemostasis, biliostasis and adhesions in peritoneal cavity. Specimens of the hepatic tissue were fixed in 10 per cent neutral formalin solution. Sections were made perpendicular to the plane of laser welding and

were stained with azure and eosin, also with fuchsin to appreciate the development of elastic fibers.

These methods of research revealed the microcirculatory failure in welding area due to dissipation of laser energy, that caused hyperemia, stasis and perivascular diapedesis. Maximal discirculatory disturbances were detected after 24 hours, though these changes weren't essential for reparation processes. Reparation of welded wounds goes with aseptic productive inflammation, that characterized with proliferation of cells of macrophageal system. This activated angiogenesis, and fibroblast proliferation, that brings to quick development of proliferative phase of inflammatory process. No exude was seen in peritoneal cavity on the first day after operation. Macroscopically welding suture was represented as brownish thin line. When welding performed at 4 watt and higher power settings the hyperemia in welding area and adhesions between liver and omentum that didn't require sharp dissection, were presented.

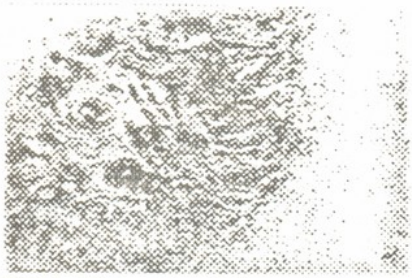

Fig.1 The granulation tissue in the laser welding zone at third days after operation. It composed of chaotically disposed new capillaries, proliferating macro-fags and fibroblast cells. Eosin stain 100^{x}.

Already on the third day the granulation tissue was developed, that contained chaotically disposed new capillaries, proliferating macrofags and fibroblasts (Fig.1), it also contained polymorpho-nuclear leukocytes and plasmatic cells. Fibroblasts had round form and bazophilic cytoplasm, that characterized by poorly differentiated connective tissue cells, with high synthesize and proliferative function. Granulation contained structureless, homogeneous, oxiphilic necrotic material. Macroscopically at the welding site whitish line was on the liver surface, with less or no hyperemia around.

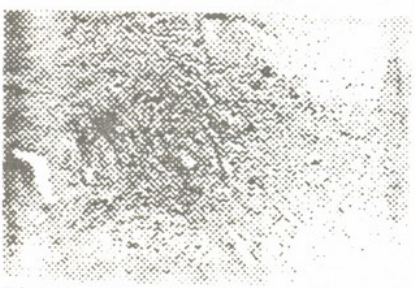

Fig. 2. The granulation tissue in the laser welding zone at 7-th days after operation. The linear granulation tissue contained immature collagen fibers, sinuous blood vessels and fragments of necrotic tissue. Eosin stain 100^{x}.

On the 7-th day laser influence zone was composed of linear granulation, with basophilic intercellular tissue. Still the slight leukocyte infiltration remained. At that time granulation tissue contained immature slightly fuchsinophil collagen fibers, sinuous blood vessels and few necrotic tissue (Fig.2). Fibroblasts had spindlelike form and oval or stab nuclei. Also macrophages were presented, and their contact should release fibrinogenic factor, which activates collagen formation. Visually whitish line of the suture was nearly imperceptible and no hiperemia was seen. From the first day of operation, under high energy power welding, moderate udhesions were observed in operating area, that easily became free with blunt dissection.

Mature granulation tissue was formed in welding area on the 14-th day. Great amount of fuchsinophil collagen fibers appeared, capillary amount decreased. Welding area contained less coagulated substance and single fibroblasts with extremely decreased synthesize activity. Hepatocyts were less basophilic and their nuclei became normal. Macroscopically the welding area wasn't distinguished from the around normal tissue and the suture was almost imperceptible too. The adhesions were severe at high

energy powers of performing laser welding, with the omentum becoming adherent to the site of welding. It required sharp dissection to free the adhesions.

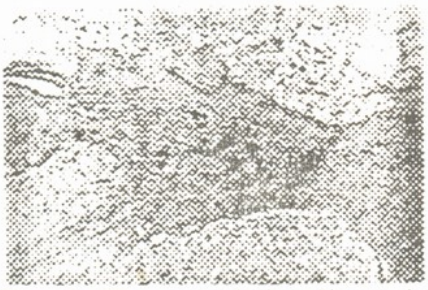

Fig. 3. The granulation tissue in the laser welding zone at 21-t days after operation. The gigantic cell prolifera-tes around remained few coagulated substance were seen among the mature collagen fibers. Fuchsin stain 100^{x}.

On the 21-st day after operation the formed connective tissue in welding area contained few capillaries, single leukocytes and less necrotic tissue. On the 30-th day the fine, thin scar was formed. The gigantic cell proliferates were seen around the remained few coagulated substance in the formed fibrose tissue.

Thus our experiments have shown, that by welding the cut liver wounds it is possible to get full hemostasis and reliable biological hermetic state that is due to minimal swelling, little leukocyte infiltration and exudation of tissue in welding area and better course of reparation of the welded wounds. We think that laser welding combined with traditional operating methods of the parenchimal injured organs can be successfully applied in clinical practice.

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PALAEOBIOLOGY

E.Kharabadze

The Main Results and Prospective of Study of the Caucasian Fossil Snakes

Presented by Academician L. Gabunia 03.05.1995

ABSTRACT. **The paper sums up the study of fossil snakes of the Caucasus. Nowadays only 11 localities are known.There are 14 species (5 genera of 3 families) from the Neogene and Pleistocene strata.**

In Neogene and Quaternary deposits of the Caucasus the fossil remains of snakes are to be found quite often. This group nowadays is almost unstudied. This paper deals with the history of study of this question and the list of localities with the fossil remains of snakes is given. The systematical list of fossil snakes known for this moment from the Caucasus with proper localities is also given.

The first information about existing of fossil remains of snake in the Caucasus belongs to Palibin who mentioned them in the paper about Akchagilian flora of Azerbaijan, from the locality studied by him [1]. The following information we can find in V.Bogachov's paper [2]: "In Southern Kakhetia (Eastern Georgia, E.Kh.), from Mirzaani (Shiraki's region) to Eldar coloured clayey sediments are located, where remains of *hipparion, rhinoceros, dinotherium* and folded *Unio flabellatus* were discovered. In the most lower parts of these sediments the remains of fishes, snakes (water snakes?), turtles, *Limnea, Planorbis, Valvata, Bithinia* and *Pisidium* were found".

In 1950-1970 L.Khozatski and N.Burchak-Abramovich studied the fossil herpetofauna of the Caucasus and remains of snakes. As these remains in collections before this time were always scanty,they were not well enough examined: "Remains of lizards and snakes in fossil condition are to be found comparatively rarely because of their usually small measurements and fragility. Nowadays from the territory of the USSR only several fragments of skeletons of extinct specimens of these animals are known. For the present in the Caucasus only 2-3 such kind of fragments are found"[5].

Comparatively perfectly the fossil remains of snakes in the last several years were explored by V. Chkhikvadze and G. Zerova. The main part of materials found for this moment is preserved in the L. Davitashvili Institute of Palaeobiology of the Georgian Academy of Sciences. It must be mentioned that up to now we have only two papers with complete descriptions of remains of the Caucasian fossil snakes [3,4].

Information given below is based on the territorial principle. For each region an alphabetical list of localities is given with proper references.

ARMENIA

EREVANI CAVE - presents rather rich herpetofauna and also remains of snakes (Palaeolithic, Mousterian). This collection is not examined yet.

NURNUS - on the river Zanga. Among other reptiles were found: *Erix sp., Colubridae* (2 or 3 species) and *Daboia cf. xanthina* (End of Early Pliocene) [12].

AZERBAIJAN

BINAGADI - according to N.Vereshchagin about 100 fragments of turtles, lizards and snakes were found [6]. More concrete information is not published till now [7]. This locality is dated with Middle Pleistocene.

NAFTALAN - I. Palibin has mentioned about the remains of fossil snake in Akchagilian deposits [1].

GEORGIA

ARUKHLO - village Arukhlo on the river Khrami. Here remains of the following snakes were found: *Natrix sp., Daboia lebetina* (Pleistocene); [8].

DMANISI - *Coluber najadum, Coluber schmidti, Coluber robertmertensi, Boiga cf. trigonata, Daboia cf. raddei* (Upper Pliocene-Lower Pleistocene, determined by V.Chkhikvadze and E.Kharabadze).

IORI'S VALLEY - exact location is unknown.Here were found: *Ophidia indet.* (*Natrix?*). Dated with Upper Sarmatian [2].

KUDARO - *Natrix natrix* (Early Palaeolithic) [4].

RUSTAVI = IAGHLUJA - *Daboia sp.* (Upper Sarmatian) [3]; "The big *Vipera sp.*"[9].

SHVALIETI - *Colubrinae indet.* (Mousterian; Determination of V.Chkhikvadze) [10, 11].

NORTHERN CAUCASUS

BELOMECHETSKAIA - *Natricinae gen. indet., Coluber sp., ?Boiga sp., Colubridae gen. indet., Daboia sp.* (Middle Miocene) [13].

The List of the Caucasian Fossil Snakes

Classification and sequence of taxa are given by Jean-Claude Rage [14]; See also [15].

Order *Ophidia* (=*Serpentes*)

Ophidia indet. - BINAGADI

Ophidia indet. - NAFTALAN

Ophidia indet. - EREVAN-I

Ophidia indet. (*Natrix?*) - IORI'S VALLEY

Suborder *Alethinophidia*

Superfamily *Booidea*

Family *Boidae*

Subfamily *Erycinae*

Genus *Erix*

Erix sp. - NURNUS

Superfamily *Colubroidea*

Family *Colubridae*

Colubridae gen. indet. - BELOMECHETSKAIA

Colubridae indet. - NURNUS

Genus *Boiga*

?Boiga sp. - BELOMECHETSKAIA

Boiga cf. trigonata - DMANISI

Subfamily *Colubrinae*

Colubrinae indet. - SHVALIETI

Genus *Coluber*
Coluber sp. - BELOMECHETSKAIA
Coluber najadum - DMANISI
Coluber robertmertensi - DMANISI
Coluber schmidti - DMANISI
Subfamily *Natricinae*
Natricinae gen. indet. - BELOMECHETSKAIA
Genus *Natrix*
Natrix sp. - ARUKHLO
Natrix natrix - KUDARO
Family *Viperidae*
Subfamily *Viperinae*
Genus *Daboia*
Daboia sp. - RUSTAVI
Daboia sp. - BELOMECHETSKAIA
Daboia cf. raddei - DMANISI
Daboia cf. xanthina (=*raddei*) - NURNUS
Daboia lebetina - ARUKHLO

The List of Localities of the Caucasian Fossil Snakes by Stratigraphical Sequence

MIDDLE MIOCENE - Belomechetskaia
UPPER SARMATIAN - Iori's Valley, Rustavi
END OF EARLY PLIOCENE - Nurnus
AKCHAGILIAN - Naftalan
UPPER PLIOCENE - LOWER PLEISTOCENE - Dmanisi
MIDDLE PLEISTOCENE - Binagadi
PLEISTOCENE - Arukhlo
EARLY PALAEOLITHIC - Kudaro
PALAEOLITHIC, MOUSTERIAN - Shvalieti, Erevan- I

The main part of the above-mentioned materials were obtained by new special method with sifting and washing of friable small-grained sediments.This method allows to obtain more small fragments of fossil reptiles and particularly that of snakes [7].

As it is known, reptiles and particularly snakes are fine indicators of ecological habitat. Their stenobiontivity allows us to determine exactly and clearly many parameters of surroundings of geological past. The results of study of fossil snakes can be used to clear up morphology and phylogenesis of separate groups, time and direction of prochoresis and also the stratigraphical correlations. All this allows us to consider that the study of the Caucasian fossil snakes is quite prospective business.

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PHYLOLOGY

M.Karbelashvili

Rustaveli's Poem "The Knight in the Panther's Skin" within the Context of Comparative Studies

Presented by Academician G.Tsitsishvili July 18, 1996

ABSTRACT: **According to the principles of comparative studies on the basis of analysing scientific literature it has been concluded that "The Knight in the Panther's Skin" belongs to the West European type of literature. The most important in solving the problem is the conception of the woman in Rustaveli's poem.**

"Everything can be realized by means of comparison," this is a well known saying, but comparison has its limits: the historical-typological method of comparison brings to important result, when observing the principle of historism and comparing similar phenomena. The internal kingship of Shota Rustaveli's poem "The Knight in the Panther's Skin" to the Europ an romances namely to those by Chrétien de Troyes and Wolfram von Eschenbach was noticed long ago both by Georgian and foreign scholars [1;2]. This problem is discussed in numerous scientific works of Georgian, Russian and some European scholars. Very often these works contain contradictory ideas. A critical study and analysis of those works and hence coming to suitable conclusions will make clear some problems in the comparative study of Rustaveli's poem "The Knight in the Panther's Skin" and Arthurian romances.

The XII century romances are the most significant thesaurus of the European literary heritage, they are directly connected with the leading ideology of the Middle Ages – Christianity. The works of Chrétien de Troyes, of Wolfram von Eschenbach and of Shota Rustaveli owe a lot to the Christian religion, its ideas and symbols: these writers created their own system of morality where woman occupies the most honourable place which is known by a special term "the cult of woman" or "the worship of the woman" [3,1]. This idea proves that Rustaveli's poem is spiritually related to the XII century European romance.

Nevertheless in Rustvelological literature *a priori* is accepted the thesis that Oriental, namely Persian literature has more in common with Rustaveli's poem. The main argument referred to is that at the junction of the XI-XII centuries Georgia had no direct relations with the literary life of Western Europe [4, 253; 5, 169]. There the neighbourly contacts are considered to be of decisive importance and no attention is paid to the fact that as early as at the beginning of this century Niko Marr, a well-known scholar emphasised the importance of comparing Shota Rustaveli's poem with a similar phenomenon in the life of the Middle Ages Europe. He gave a scholarly analysis of the cult of the woman and of chivalry as presented in the poem "The Knight in the Panther's Skin" [3, I-LVI], but this right idea was neglected and in the comparative studies of the Soviet period according to the accepted tradition scholars studied the poem proceeding from the "geographical principle" and considered it to be belonging to the "romantic epos of the Near East" [6, 35; 7, 337; 8, 197-216]. "Romantic epos of the Near East" means Persian literature and comparing it with Shota Rustaveli's poem is nothing but abusing the facts, as there is a great difference between

the Christian and the Moslem world outlooks, as both the cult of the woman and chivalry are unknown to the Moslem Orient. This is a case when *Comparison n'est pas raison*, the more so as both the cult of the woman and chivalry are unknown to the Moslem Orient [8; 155,183,206].

Having studied and analysed numerous works in comparative studies dedicated to the problem I have found out why the comparative studies of the Soviet period (I mean scientific works by Russian scholars) studied "The Knight in the Panther's Skin" within the context of Oriental i.e. Persian literature: Soviet comparative study principally opposes "Europocentrism," viewing it tendenciously; it rejects the existence of "European type of literature" considering it as "historical prejudice" [6,156]. It is keeping with these ideological principles that "The Knight in the Panther's Skin" is pulled out of its organic European i.e. Christian soil and is artificially included in a quite different literary type. In spite of the fact that Georgia – a stronghold of Christianity in the Near East – was severed from Europe for centuries it was in Georgia that a romance, which was analogous to West European romance was created. A thorough study of the problem will reveal many similarities and no less differences between them but it is more important that "The Knight in the Panther's Skin", as a creation of Christian literature, should be studied parallel with the West European romances of XII century as a typological analogy.

The question of the conception of the woman in the works of three great writers of the twelfth-century Christian world – Shota Rustaveli, Chrétien de Troyes and Wolfram von Eschenbach, i.e. the conception of the woman in the medieval Christian world calls for the study of "The Knight in the Panther's Skin" in the light of comparative studies. This problem, as it now exists in Rustvelology, is rather complicated, demanding more clarity. Taking into consideration the history of the question the following problem crops up: how the relation of "The Knight in the Panther's Skin" with the Oriental or Moslem and Western or Christian literatures is represented in Rustvelology.

Though searching for the original of "The Knight in the Panther's Skin" or some analogous works is as hopeless as looking for the originals of Montesquieu's "Persian Letters" in Persia, more than a century ago, Niko Marr, a well-known scholar, created a biased theory that "The Knight in the Panther's Skin" had been translated from Persian. His theory was caused by "the theory of influences" widespread in comparative studies at that time; according to this theory literature of nations is created by the influence of those "world" or imperial nations under whose political pressure the former are (towards the end of his life Marr came to the conclusion that "the theory of influences" had failed). The *error fundamentalis* of his theory was caused by the fact that the words "this Persian tale" [9] in the prologue of Rustaveli's poem was understood by Marr in their direct lexical meaning, as a geographical name, thus ignoring the specific features of the poetic language of Rustaveli, the metaphors employed by the poet; since the words *Persia* and *Persian* have their semantics which is the result of only European thinking (Herodotos, Aischylos, Plato), with Rustaveli they have the same metaphoric semantics as in the works of Dante, Montesquieu, and Goethe [9, 172].

But it is important to note that in the works of Marr himself, there was a significant idea contradictory to his own thesis of "The Knight in the Panther's Skin" being of Persian origin and proving its being wrong. It is especially interesting that this problem is connected with the conception of the woman, the very question that ruined Marr's theory. The contradictory character of Marr's works on Rustvelology was revealed by the fact that it was Marr who paid attention to and studied the questions of the cult of

the woman and of the chivalry in "The Knight in the Panther's Skin" and came to a conclusion, that both problems are analogues of those existing in Christian Europe [3,1]; it was Marr who emphasized that "it is high time to compare Shota Rustaveli's poem with the analogous phenomenon in Medieval Europe", he also specially noted that "similar and sometimes identical features can be found in the literature of those countries who lacked the possibility if interrelation" [3, VIII]. In spite of the fact that in his following works Marr continued keeping to his theory of the Oriental genesis (though in a milder form) of "The Knight in the Panther's Skin", with an unbiased attitude of a scholar he noted that "comparatively closer parallels of the poem can be found in Western Europe" [10, 74], he also emphasized that the cult of the woman as given in the poem was of great importance, because "all the known literary works of the Moslem Orient lacked this element" [11, 421]. Marr treated this fact as an ideological independence of "The Knight in the Panther's Skin" explaining it by the real historical life of Georgia, because "as early as in the 11th-12th centuries there was literary evidence to prove the original development of the cult of the woman" [11, 423].

V.F.Shishmarjov, a great expert on West European literature agreed with Marr and thought that "The Knight in the Panther's Skin" was based on the Persian origin, but he could not refer to any fact to prove his theory: it remained an abstract thesis while the concrete facts proved something quite different. The parallels and analogues between "The Knight in the Panther's Skin" and West European literature referred to by V.F.Shishmarjov are very significant: the scholar thinks that in Rustaveli's poem there is a new conception of love; it is depicted not as a passion – *passio*, but as a sentiment, an eternal memory of the beloved and a permanent moral perfection under the influence of this feeling: the heroic deeds of the knight are dedicated to the woman [7, 356]; love, depicted by Rustaveli, comes from a noble heart, the noble heart and the love are the same, as it is in French literature: *amor e cor gentil son una cosa* [7, 346]. Analogues to the women, depicted in "The Knight in the Panther's Skin", who are devoted to their motherland, are capable of independent actions and take part in the court cerempnies can be found neither in Persia nor in Arabia. [7, 348]. From the point of view of literary monism similar analogues make it possible to link the extreme West of Europe with the extreme Orient, which seem so far apart at first sight and almost in the same epoch. As it seems, says V.F.Shishmarjov, in both cases we deal with one and the same stage of development which is expressed as vividly and originally in Georgia as it is in France [7, 356].

From the standpoint of Oriental inertia "The Medieval Romance", a fundamental work by E.M.Meletinski is more interesting; he studies "The Knight in the Panther's Skin", a work created on the basis of Christian culture, within the limits of the romantic epos of Moslem Iran and that of the Persian language Azerbaidjan ("The Romantic Epos of the Near East and Persian-language Azerbaidjan"), thus separating it from the first part of the work, where he deals with the twelfth-century West European romance. In spite of this artificial division, the unbiassed scientific attitude is so strong that if we put together all the analogues and parallels scattered in E.M.Melitinski's work, it will be clear that "The Knight in the Panther's Skin" has more in common with the contemporary West European romance than with the Oriental romantic epos. E.M.Melitinski thinks that the theory and the practice of love in "The Knight in the Panther's Skin" reveal the influence of Arabian and Persian characteristic features, but Rustaveli's original conception of love and chivalry is closer to the Medieval courtly ideals [8, 207]. E.M.Meletinski several times points out that Rustaveli's attitude

towards Gurgani, the author of Persian romantic epic "Vis and Ramin" is polemical [8, 204], here I would like to note: as polemical as Chrétien de Troyes is polemical towards "Tristan"; Rustaveli praises the lofty love, Gurgani - carnal love; there is adultery in Gurgani's "Vis and Ramin" while the objects of love of Rustaveli's heroes are the maidans of the royal descendance, who afterwards become their wives [8, 206]; merging a wife or fiancée and a woman in one person is alien to the poetry of Provence but it can be found in most of Chrétien's novels; Rustaveli reveals analogous features [8, 210]. E.M.Meletinski notes that in "The Knight in the Panther's Skin" there is Georgian patriotism and Christian tenderness [8, 215].

When analysing these works in the light of comparative studies we come across a paradox that is extremely surprising: all these scholars link Rustaveli's poem with oriental literature, but the facts presented in their works prove the opposite; thus, facts contradict their theory.

There are two ways of revealing interrelation by means of comparison: similarity and difference. "The Knight in the Panther's Skin", as a work created on the basis of Christian ideology, is akin to the twelfth-century West European romance and differs from the Persian romantic epos of the same epoch. From the point of view of the idea of world literature the study of the works of the great twelfth-century writers – Rustaveli, Chrétien de Troyes, Wolfram von Eschenbach and Nizami – in the aspect of comparative studies, when special attention is paid to conception of the woman will open up an interesting new stage in the study of world literature. *Les beaux esprits se recontrant,* that is why men of genius understand each other very well – this is the humanistic basis of the integrirty of the world literature, because the geniuses understand each other from the point of view of these humanistic ideas. A man of genius, whichever nation he may belong to, can not fail to be a humanist as well; only the ways of expressing this humanism may differ, due to the ideological and artistic traditions immanent in this or that nation. In my opinion the Oriental-Occidental synthesis of Rustaveli, of this most enigmatic writer, in the complicated medieval epoch first of all is revealed in the tolerance which imbues the whole poem and grants Rustaveli the honour to be considered the forerunner of Lessing and Goethe.

After everything, that has been said above, it seems that it is time to finally overcome the groundless theory of Rustaveli's poem being of Persian origin and to discuss "The Knight in the Panther's Skin" as the work created on the basis of Christian culture and to study it in the context of West European literature as an integral part of the former.

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OFFERED

Treatment of Psoriasis

Basic Principles

Based upon our own experience we suggested neurogenic stress as a basic reason for psoriasis. Manifestation of the disease depends upon genetic features.

We analysed case histories of 52 patients during the period 1994 - 1995. In 39 (75%) instances the reason for the disease was psychic shock. Among them 11 persons were veterans of the war in Afghanistan and 28 patients were refugees from Abkhazeti.

The reception of psychotropic medicines and immunodepressants is advised. Skin lesion's treatment includes appropriate hormonal therapy, phytotherapy, balneoprocedures and thalassotherapy as well.

While giving the patients psychotropic drugs, it's necessary to settle down skin lesion. In order to do this embrocation of citrus plants' extracts together with corticosteroid ointment is recommended.

Together with all this immunomodulators and antimetabolic drugs should be prescribed. During the treatment process the reception of sulphuric thermal mineral baths should be alternated with thalassotherapeutic procedures on a seashore.

Such procedures should be repeated several times.

P.Shoshiashvili
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37-31-59

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