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CORE-MANTLE BOUNDARY VELOCITY FIELD RECOVERING FROM A FOUR-CENTURY GEOMAGNETIC FIELD MODEL

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ABSTRACT

The present paper provides information about a new method of the velocity field calculation at the Core-Mantle Boundary (CMB) of the Earth when both the radial geomagnetic field and its secular variation (SV) are known. The fluid flow in the outer core is considered to be under the frozen-flux approximation. The simplified induction equation for the radial component is here involved. The velocity field is separated into a toroidal and poloidal part. The radial geomagnetic field and its secular variation and the toroidal and poloidal ingredients of the velocity field are expanded in spherical harmonics series. The maximum degrees of these expansions are chosen in such a way to match the number of unknown coefficients of the velocity field expansion with the number of algebraic equations. The Gauss coefficients of the geomagnetic field spherical harmonic expansion and their SV are taken from the **gufm1** model. The system of equations is then inverted by a standard matrix inversion procedure. The recovered maps of the velocity field show a pronounced feature under the South Atlantic and Indonesian archipelago and other features that agree with those reported by other authors.
Keywords: core-mantle boundary, velocity field, frozen flux approximation, Gauss coefficients, secular variation

1. INTRODUCTION

Currently, it is well confirmed that the structure and evolution of the geomagnetic field are governed by the fluid convective motion in the

terrestrial outer core. This motion is responsible for the generation and maintenance of the planetary magnetic field, known as main field, through a dynamo mechanism (Moffatt *et al*, 1978; Backus *et al*., 1996; Duka, 1998; Rüdiger and Hollerbach, 2004). This field is practically dipolar if measured at the Earth's surface. However, inside the outer core the picture is rather complicated because the higher moments of the magnetic field become important (Backus *et al.*, 1996). There has been extensive research activity on studying the patterns of fluid convection that could emerge in the outer core from experiments (Petrelis *et al*., 2009) as well as from numerical simulations (Kageyama and Sato, 1997).

The large-scale fluid flow in the outer core and the patterns that emerge are considered to be the main drivers of the geomagnetic field evolution and, especially, of the polarity reversals (Schmitt *et al*., 2001). Simple stochastic models have been also constructed to model the geomagnetic reversals of the dipolar geomagnetic field (Duka *et al*., 2015; Peqini *et al*, 2015).

It is strongly believed that the small-scale fluid convective motion affects and drives the temporal evolution of the main field, known as secular variation, SV (Backus *et al*., 1996; Dormy and Soward, 2007). Furthermore, probably the fluid motion in the core-mantle boundary (CMB) which is the physical boundary between the liquid outer core and rocky lower mantle, is crucial for the determination of the SV patterns observed on the Earth's surface (Bloxham and Gubbins, 1991; Whaler *et al.*, 2016). Recently, there have been some successful efforts to describe the SV of the dipolar field even with stochastic models which offer valuable insights (Schmitt *et al*., 2001; Duka *et al*., 2015; Peqini *et al*, 2015). The fluid flow that governs this process is concentrated in a very thin layer located in the uppermost part of the core, just beneath the CMB (Backus and Le Mouël, 1986). The thickness of the layer is much smaller compared to the other dimensions (this layer is extended to the whole CMB) and allows us to consider the flow to be 2-dimensional. Consequently, the velocity of the fluid, which characterizes the fluid flow, has only two components, v_θ and v_φ.

It is very important to recover this velocity to provide insights on the fluid convection and dynamo mechanisms (Bloxham and Gubbins, 1991). The corresponding information so obtained from these velocity field maps can provide short-term predictions of the SV (Beggan and Whaler, 2010) and important insights in the changes of Length of Day, LoD (Hide, 1993). In addition, some studies show that the velocity field at the CMB can be used to study the lateral variations of the electrical conductivity of the mantle (Holme, 2000). In principle, the velocity map enables also the calculation of various torques exerted on the fluid into the core by the surrounding mantle (Deleplace and Cardin, 2006).

An important topic is the relation between jerks and fluid flow at the CMB. Jerks are sudden changes in the trend of the SV of the geomagnetic field. Such phenomena consist in changes from a positive trend (increasing field magnitude) to a negative one (decreasing field magnitude) and vice versa and occur in less than one year, so more rapidly than usual secular variations (Duka *et al*., 2012). It is believed that these events are related with corresponding sharp changes in the pattern of fluid flow at the CMB (Moffatt, 1978; Backus *et al*., 1996). Through the method described below we aim to study such relationship. However, in this paper we report the first stage of our ongoing work. The relation between jerks and fluid flow at the CMB will be reported in a forthcoming paper.

There is a well-known relationship between the time evolution of the magnetic field and the fluid flow as described by the magnetic induction equation (Backus *et al*., 1996)

$$\frac{\partial \vec{B}}{\partial t} = \nabla \times \left(\vec{v} \times \vec{B} \right) + \eta \nabla^2 \vec{B} \qquad (1)$$

where $\vec{B}$ is the magnetic field, $\vec{v}$ is the velocity of the fluid and η is the magnetic diffusivity (Moffatt, 1978; Dormy and Soward, 2007). In principle, if the velocity field, i.e. the fluid flow, is known analytically or numerically, together with the boundary conditions, then the magnetic field and its rate of change or SV can be calculated. Theoretically, it is possible to pose the inverse problem, that is recovering the fluid velocity field from knowing the magnetic field and its SV.

The fact that the velocity is 2-dimensional and there is only one available equation means that the flow is inherently non-unique (Bloxham and Gubbins, 1991; Hide *et al*., 1993). To solve this problem different constraints can be imposed. Most frequently it is invoked the assumption that the flow in the upper layers of the core is under the conditions of the geostrophic balance with the pressure field (Backus and Le Mouël, 1986; Hide *et al*., 1993). This assumption is quite strong, so other more relaxed constraints can be applied.

Recent studies show that the application of constraints is not crucial to obtain the velocity field in the CMB (Aubert *et al*., 2013; Whaler *et al*., 2016). If the magnetic field, SV and velocity field are expressed in series of spherical harmonics and spherical coefficients (i.e., the Gauss coefficients), we obtain an algebraic system of equations where the Gauss coefficients of the velocity components can be determined. This procedure is detailed in section 2. The magnetic field and SV are assumed to be known. These quantities may be obtained directly from the measurements in the geomagnetic observatories (Whaler et *al*., 2016) or the results of simulations of numerical dynamo models (Aubert, 2013). In this paper we have explored another possibility: we make use of the Gauss coefficients as provided by the **gufm1** model which is

based on the best historical magnetic measurements and describes the magnetic field from 1590-1990 (Jackson *et al*., 2000).

The structure of the present paper is as follows: in section 2 we describe the main equations and the technique used to obtain the Gauss coefficients of the velocity field at the CMB. In section 3 we give the maps of velocity obtained for several epochs and discuss the results. In section 4 we provide some conclusions.

2. MATERIALS AND METHODS

A very important aspect of the flow at the CMB is that there is valid the frozen-flux approximation (Roberts and Scott, 1965; Kahle *et al*., 1967). Under this assumption, the fluid is considered to be a perfect conductor and any diffusion of the magnetic field, i.e. η is neglected (η is inversely proportional to the conductivity). Thus equation (1) becomes:

$$\frac{\partial \vec{B}}{\partial t} = \nabla \times \left(\vec{v} \times \vec{B} \right). \qquad (2)$$

Roberts and Scott (1965) applied this approximation to the fluid convection in the outer core. Then their calculations were improved and extended by Kahle *et al*., (1967). Shortly afterwards the frozen-flux approximation was also applied to SV (Backus, 1968). In this paper we will work in the framework of the frozen-flux hypothesis and will start our analysis from equation (2).

The components of the magnetic field are measured at the Earth's surface by means of the geomagnetic observatories or repeat stations as well as satellites at their altitude. However, we can calculate the magnetic components at the CMB through the downward continuation. This procedure is possible because the mantle is considered to be a poor electrical conductor, i.e. there are not any magnetic field sources, and the dipolar character of the main field is nearly preserved even close to the CMB (Backus, 1986; Backus and Le Mouël, 1986; Backus *et al*., 1996). Thus, the components of the geomagnetic field at any radial distance r are given as:

$$B_r = -\sum_{l=1}^{L_{\max}} \sum_{m=0}^{l} (l+1) \left(\frac{a}{r}\right)^{l+2} \left[g_m^l \cos(m\varphi) + h_m^l \sin(m\varphi) \right] Y_m^l (\cos\theta)$$

$$B_\theta = -\sum_{l=1}^{L_{\max}} \sum_{m=0}^{l} \left(\frac{a}{r}\right)^{l+2} \left[g_m^l \cos(m\varphi) + h_m^l \sin(m\varphi) \right] \frac{dY_m^l (\cos\theta)}{d\theta}$$

$$B_\varphi = -\sum_{l=1}^{L_{\max}} \sum_{m=0}^{l} m \left(\frac{a}{r}\right)^{l+2} \left[-g_m^l \sin(m\varphi) + h_m^l \cos(m\varphi) \right] \frac{Y_m^l (\cos\theta)}{\sin\theta}$$

where the spherical polar coordinates are employed, and a = 6371 km is the mean Earth radius. Thus, we can calculate the corresponding components of the magnetic field in every point of the CMB by substituting r with the core's radius c = 3473 km. Please note that if the mantle were a good conductor, thus containing currents, i.e. sources of magnetic field, this procedure would not be possible. Using classical electrodynamics (Jackson, 1999) it is easy to show that only the radial component of the magnetic field is continuous through the CMB. Therefore, we take the radial component of equation (2) and perform the following calculations

$$\begin{aligned} \hat{\vec{r}} \cdot \dot{\vec{B}} &= \hat{\vec{r}} \cdot \nabla \times \left(\vec{v} \times \vec{B} \right) = -\nabla \cdot \left[\hat{\vec{r}} \times \left(\vec{v} \times \vec{B} \right) \right] \\ &= -\nabla \cdot \left[\vec{v} \left(\hat{\vec{r}} \cdot \vec{B} \right) - \vec{B} \left(\hat{\vec{r}} \cdot \vec{v} \right) \right] = -\nabla \cdot \left(B_r \vec{v} - v_r \vec{B} \right) \Rightarrow \\ \dot{B}_r &= -\nabla \cdot \left(B_r \vec{v} \right) \end{aligned} \tag{3}$$

because the radial component v_r of the velocity at the CMB is assumed to be zero, i.e. v_r = 0 (Whaler *et al.*, 2016). In addition, the dot over B denotes the partial derivative with time. The del operator may be separated into its radial and horizontal parts:

$$\nabla = \hat{\vec{r}} \left(\hat{\vec{r}} \cdot \nabla \right) + \nabla_H = \frac{\partial}{\partial r} \hat{\vec{r}} + \nabla_H \tag{4}$$

where the horizontal part is

$$\nabla_H = \frac{1}{r} \frac{\partial}{\partial \theta} \hat{\vec{\theta}} + \frac{1}{r \sin\theta} \frac{\partial}{\partial \varphi} \hat{\vec{\varphi}}. \tag{4'}$$

After substituting (4) into (3) and making the calculations we obtain

$$\dot{B}_r + \nabla_H \cdot \left(B_r \vec{v} \right) = 0. \tag{5}$$

The second step of the method is separating of the velocity field into its toroidal and poloidal vector field (Whaler, 1986; Whaler *et al*., 2016). In the literature, the term poloidal is used to describe the second constituent but is not meant the 3-dimensional poloidal vector field. Instead there is taken in consideration the 2-dimensional poloidal field discussed in (Backus *et al*., 1986). The toroidal-poloidal decomposition of the velocity field reads:

$$\vec{v} = \vec{v}_T + \vec{v}_S \tag{6}$$

where T and S are the toroidal and poloidal scalar fields. The two constituents explicitly are

$$\begin{aligned} \vec{v}_T &= \nabla \times \left(\vec{r} T \right) = \left(0, \frac{1}{\sin\theta} \frac{\partial T}{\partial \varphi}, -\frac{\partial T}{\partial \theta} \right), \\ \vec{v}_S &= \nabla \times \left[\nabla \times \left(\vec{r} S \right) \right] = \nabla_H \left(rS \right) = \left(0, \frac{\partial S}{\partial \theta}, \frac{1}{\sin\theta} \frac{\partial S}{\partial \varphi} \right) \end{aligned} \tag{7}$$

Thus, the overall velocity field at the CMB reads:

$$\vec{v} = \left(0, \frac{1}{\sin\theta} \frac{\partial T}{\partial \varphi} + \frac{\partial S}{\partial \theta}, -\frac{\partial T}{\partial \theta} + \frac{1}{\sin\theta} \frac{\partial S}{\partial \varphi} \right) \tag{8}$$

Substituting (8) into (5) and performing the calculations we obtain:

$$\begin{aligned} \dot{B}_r = &-B_r \left(\frac{1}{r} \frac{\cos\theta}{\sin\theta} \frac{\partial S}{\partial \theta} + \frac{1}{r} \frac{\partial^2 S}{\partial \theta^2} + \frac{1}{r \sin^2\theta} \frac{\partial^2 S}{\partial \varphi^2} \right) \\ &- \left(\frac{1}{r \sin\theta} \frac{\partial T}{\partial \varphi} + \frac{1}{r} \frac{\partial S}{\partial \theta} \right) \frac{\partial B_r}{\partial \theta} + \left(\frac{1}{r \sin\theta} \frac{\partial T}{\partial \theta} - \frac{1}{r \sin^2\theta} \frac{\partial S}{\partial \varphi} \right) \frac{\partial B_r}{\partial \varphi} \end{aligned} \tag{9}$$

Equation (9) relates the SV of the radial component of the geomagnetic field at the CMB, the radial component of the geomagnetic field itself and the toroidal and poloidal scalar fields of the fluid flow.

The final step of the theoretical calculations consists of expanding $\dot{B}_r$, B_r, T and S in terms of spherical harmonics. For convenience we use the complex representation and the expansions into spherical harmonics of these quantities (Whaler, 1986):

$$\begin{aligned} B_r &= \sum_{l_1,m_1}\left(\frac{a}{r}\right)^{l_1+2}\left(l_1+1\right)g_{l_1}^{m_1}Y_{l_1}^{m_1}\left(\theta,\varphi\right) \\ T &= \sum_{l_2,m_2} t_{l_2}^{m_2}Y_{l_2}^{m_2}\left(\theta,\varphi\right) \\ S &= \sum_{l_3,m_3} s_{l_3}^{m_3}Y_{l_3}^{m_3}\left(\theta,\varphi\right) \\ \dot{B}_r &= \frac{\partial B_r}{\partial t} = \sum_{l_1,m_1}\left(\frac{a}{r}\right)^{l_1+2}\left(l_1+1\right)\dot{g}_{l_1}^{m_1}Y_{l_1}^{m_1}\left(\theta,\varphi\right) \end{aligned} \qquad (10.1\text{-}4)$$

where $g_{l_1}^{m_1}$, $\dot{g}_{l_1}^{m_1}$, $t_{l_2}^{m_2}$ and $s_{l_3}^{m_3}$ are the Gauss's coefficients for the radial component of the geomagnetic field, SV of this component, toroidal scalar field and poloidal scalar field, respectively. Y_l^m is the Schmidt semi-normalized Legendre polynomial. Equation (10.4) is simply the time derivative of equation (10.1). Substituting equations (10.1-4) into equation (9) and performing the rather complex but straightforward calculations yield:

$$\begin{aligned} \sum_{l_1,m_1}\left(\frac{a}{r}\right)^{l_1+2}\left(l_1+1\right)\dot{g}_{l_1}^{m_1}Y_{l_1}^{m_1}\left(\theta,\varphi\right) = \frac{1}{r}\sum_{l_2,m_2}\sum_{l_3,m_3}\left(\frac{a}{r}\right)^{l_2+2}\left(l_2+1\right)g_{l_2}^{m_2}\times \\ \times\left\{t_{l_3}^{m_3}\frac{1}{\sin\theta}\left[\frac{\partial Y_{l_2}^{m_2}}{\partial\varphi}\frac{\partial Y_{l_3}^{m_3}}{\partial\theta}-\frac{\partial Y_{l_2}^{m_2}}{\partial\theta}\frac{\partial Y_{l_3}^{m_3}}{\partial\varphi}\right]-\right. \\ \left.-s_{l_3}^{m_3}\left[\frac{\partial Y_{l_2}^{m_2}}{\partial\theta}\frac{\partial Y_{l_3}^{m_3}}{\partial\theta}+\frac{1}{\sin^2\theta}\frac{\partial Y_{l_2}^{m_2}}{\partial\varphi}\frac{\partial Y_{l_3}^{m_3}}{\partial\varphi}-l_3\left(l_3+1\right)Y_{l_2}^{m_2}Y_{l_3}^{m_3}\right]\right\}. \end{aligned} \qquad (11)$$

Afterwards we multiply both sides of equation (11) by the respective complex conjugates and integrate on the surface Ω of the CMB. By virtue of the orthogonality of the *Y*-polynomials we finally obtain:

$$\dot{g}_{l_1}^{m_1} = \sum_{l_3,m_3}\left[\frac{1}{r}\left(\frac{r}{a}\right)^{l_1+2}\frac{1}{(l_1+1)}\sum_{l_2,m_2}\left(\frac{a}{r}\right)^{l_2+2}(l_2+1)g_{l_2}^{m_2}\times\right.$$
$$\left.\times\oint_\Omega\frac{1}{\sin\theta}Y_{l_1}^{m_1*}\left(\frac{\partial Y_{l_2}^{m_2}}{\partial\varphi}\frac{\partial Y_{l_3}^{m_3}}{\partial\theta}-\frac{\partial Y_{l_2}^{m_2}}{\partial\theta}\frac{\partial Y_{l_3}^{m_3}}{\partial\varphi}\right)d\Omega\right]t_{l_3}^{m_3}+ \qquad (12)$$
$$+\sum_{l_3,m_3}\left\{-\frac{1}{r}\left(\frac{r}{a}\right)^{l_1+2}\frac{1}{(l_1+1)}\sum_{l_2,m_2}\left(\frac{a}{r}\right)^{l_2+2}(l_2+1)g_{l_2}^{m_2}\times\right.$$
$$\left.\times\oint_\Omega\left[Y_{l_1}^{m_1*}\frac{\partial Y_{l_2}^{m_2}}{\partial\theta}\frac{\partial Y_{l_3}^{m_3}}{\partial\theta}+\frac{1}{\sin^2\theta}Y_{l_1}^{m_1*}\frac{\partial Y_{l_2}^{m_2}}{\partial\varphi}\frac{\partial Y_{l_3}^{m_3}}{\partial\varphi}-l_3(l_3+1)Y_{l_1}^{m_1*}Y_{l_2}^{m_2}Y_{l_3}^{m_3}\right]d\Omega\right\}s_{l_3}^{m_3}$$

The star here denotes the complex conjugation. These equations relate the Gauss coefficients of the SV of the radial component of the magnetic field, of the component itself and of the toroidal scalar field and the poloidal scalar field. The coefficients for the velocity constituents are found by inverting the set of the equations (12).

We can perform some simplifications in (12) and then set

$$E_{l_1l_3}^{m_1m_3} = \frac{1}{r}\left(\frac{r}{a}\right)^{l_1+2}\frac{1}{(l_1+1)}\sum_{l_2,m_2}\left(\frac{a}{r}\right)^{l_2+2}(l_2+1)g_{l_2}^{m_2}\times\oint_\Omega\left(\frac{\partial Y_{l_3}^{m_3}}{\partial\theta}\frac{\partial Y_{l_2}^{m_2}}{\partial\varphi}-\frac{\partial Y_{l_2}^{m_2}}{\partial\theta}\frac{\partial Y_{l_3}^{m_3}}{\partial\varphi}\right)Y_{l_1}^{m_1}d\Omega \qquad (13)$$

$$G_{l_1l_3}^{m_1m_3} = \frac{2}{r}\left(\frac{r}{a}\right)^{l_1+2}\frac{1}{(l_1+1)}\sum_{l_2,m_2}\left(\frac{a}{r}\right)^{l_2+2}(l_2+1)g_{l_2}^{m_2}\times$$
$$\left[l_1(l_1+1)+l_3(l_3+1)-l_2(l_2+1)\right]\oint_\Omega Y_{l_1}^{m_1}Y_{l_2}^{m_2}Y_{l_3}^{m_3}d\Omega \qquad (14)$$

that contain the well-known Elsasser and Gaunt integrals (Whaler, 1986). There are numerous programs constructed to calculate the values of these integrals and can be found in the literature (e.g. Wolfson, 1966; Moon, 1979; Weniger and Steinborn, 1982; Xu, 1996). Thus, the rather subtle equations (12) can be written in matrix notation as

$$\dot{\mathbf{g}} = \mathbf{E}\mathbf{t} + \mathbf{G}\mathbf{s} \qquad (15)$$

where in the left side is the vector of the Gauss's coefficients of the SV, **t** and **s** are the vectors of the Gauss coefficients for the toroidal and poloidal scalar fields; **E** and **G** are the matrices which contain the corresponding values of the Elsasser and Gaunt integrals as well as the Gauss coefficients of the radial component of the geomagnetic field. All the unknown coefficients as well as the known ones are arranged properly starting from the first coefficient with degree 1 and order -1.

Equation (15) obtained by us is identical to equation (8) obtained by (Whaler *et al*., 1986). However, the ways we followed to solve it numerically are quite different. Whaler *et al*., (2016), as well as other authors, make use of the data taken from measurements in observatories around the world. They assume that the Gauss coefficients and the corresponding data are linearly related in a known fashion. Thus, they use these coefficients implicitly. Then they apply the stochastic inversion technique (Gubbins, 1983; Whaler, 1986; Aubert, 2013; Whaler *et al*., 2016). We use another method: we make use directly of the Gauss coefficients provided by the global model. Thus, there is no need to apply the stochastic inversion technique. Instead we applied a simple matrix inversion to recover the spherical harmonic coefficients of the *T* and *S* scalar fields. The obtained coefficients are then plugged into equations (7) to calculate the velocity field.

3. RESULTS

The Gauss coefficients of the SV and the magnetic field are provided by the **gufm1** model on monthly basis. We have chosen this model because it describes the evolution of the geomagnetic field for an extended recent period of four centuries. The other global models reproduce the field for much shorter intervals. Despite the validity period 1590-1990 of the **gufm1** models, in this paper we limit our calculations for the more reliable period: 1850-1990. This is since the coefficient of the dipolar field (g_1^0) is linearly extrapolated before 1850 (Jackson *et al.,* 2000). Thus, the largest coefficient is linearly biased prior to 1850 and therefore is not useful for our purposes. The magnetic field is expanded up to $l_1 = 6$ whilst the toroidal and poloidal scalar fields are expanded up to $l_2 = l_3 = 4$. The total number of equations in system (12) is: $l_1 (l_1 + 1) = 48$. Also, there are: $l_2 (l_2 + 1) = l_3 (l_3 + 1) = 24$ equations for the *T* as well as the *S* scalar fields. Thus, in the system (12) there are as many equations as there are unknowns eliminating any non-uniqueness. Consequently, there are to be determined 48 coefficients per epoch. The Gauss coefficients are given for each month for the 140 years period under

study and therefore there are in theory 1680 distinct sets. The coefficients of SV are found simply by calculating the differences between two consecutive coefficients of the radial magnetic field resulting in 1679 sets of coefficients. So, the total number of unknown coefficients to be determined is 80,592.

The codes by which we performed the numerical calculations are written and executed in MATLAB platform. The codes make use of standard routines and subroutines of spherical harmonics. Typical codes are used to make the snapshots (1679 in total). Six of them are shown in Fig. 1-6. The maps are produced using a standard cylindrical projection. The limits of latitude and longitude extend artificially beyond their typical ranges due to the projections applied but there is no problem with this reconstruction because the corresponding edges of the maps overlap.

The velocity field at the CMB should not be confused with the motion of the fluid due to the Earth's rotation. The maps in the following figures show the motion of the liquid in the outer core relative to the mantle when the last is considered to be fixed (we are in the co-rotating frame of reference). The longest arrows represent a relative motion of 20 km/yr which is in good agreement with the results of other authors (Gubbins, 1983; Whaler, 1986; Hide *et al*., 1993; Whaler *et al*., 2016).

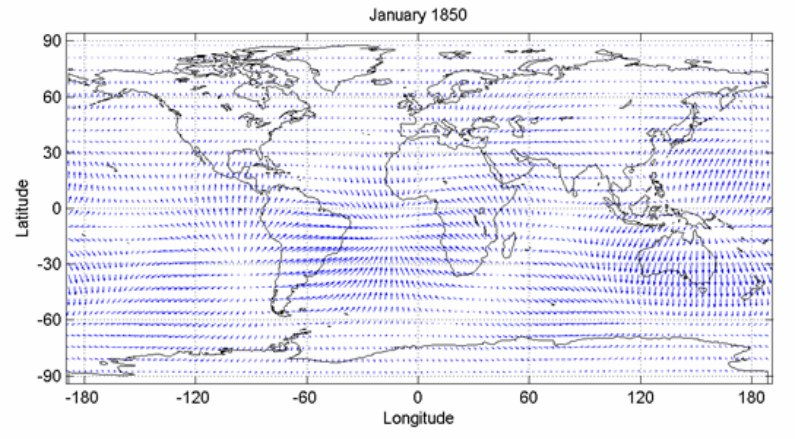

Fig. 1: Velocity field at CMB in 1850. Longest arrow is 20 km/yr.

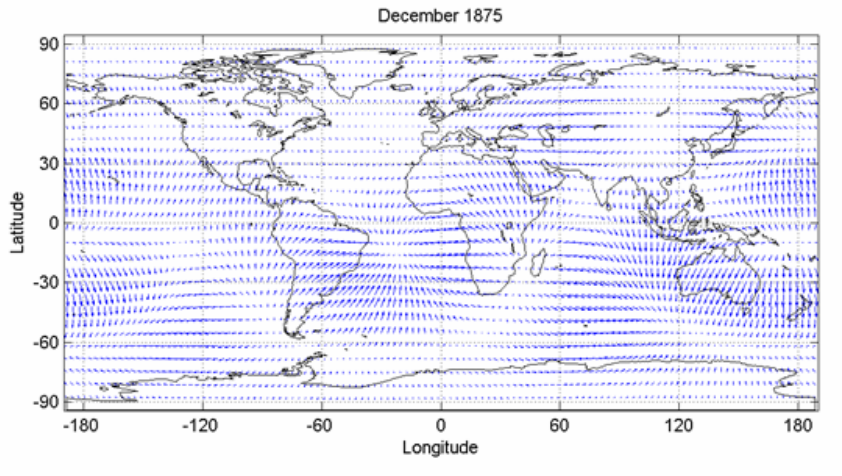

Fig. 2: Velocity field at CMB in 1875. Longest arrow is 20 km/yr.

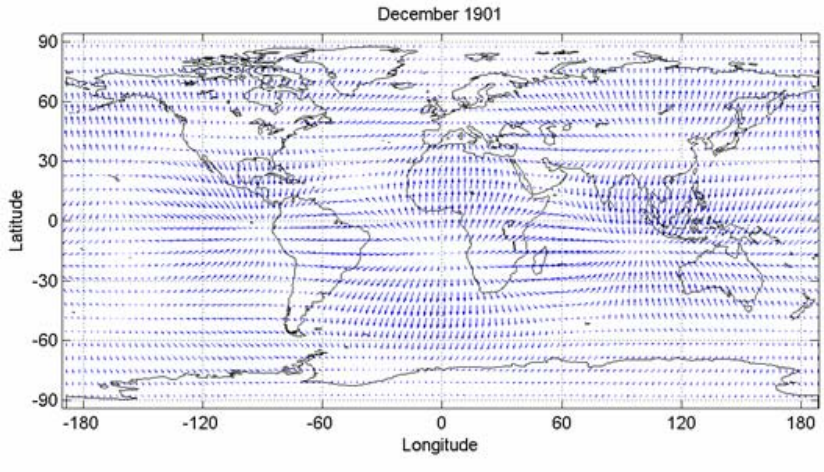

Fig. 3: Velocity field at CMB in December 1901. Longest arrow is 20 km/yr.

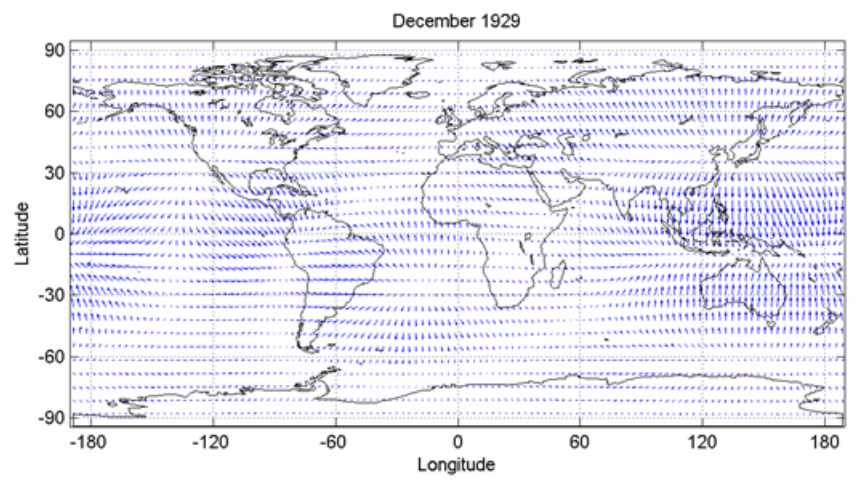

Fig. 4: Velocity field at CMB in December 1929. Longest arrow is 20 km/yr.

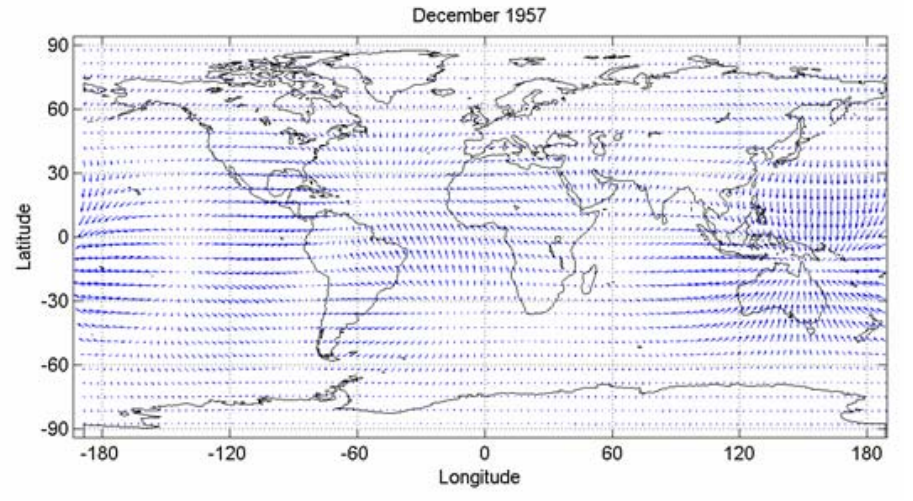

Fig. 5. Velocity field at CMB in December 1957. Longest arrow is 20 km/yr.

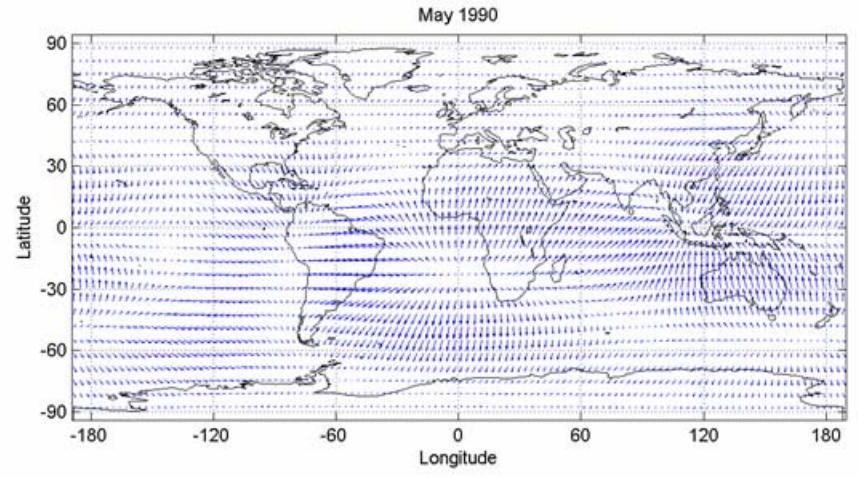

Fig. 6. Velocity field at CMB in May 1990. Longest arrow is 20 km/yr.

4. DISCUSSIONS AND CONCLUSIONS

In all the maps clearly show that the relative motion of the fluid near the poles of the CMB is very small, nearly zero. In the high latitudes it seems that the fluid at the CMB is co-rotating with the mantle. This is not the case for the flow in low latitudes or equator. There is an extended activity especially between the South America and the southern part of Africa (a zone corresponding to the known South Atlantic Anomaly, SAA). Also, there is another zone under the Indonesian archipelago.

If seen in chronological order (Fig. 1-6), these features initially seem to move westward, then become weak and then reappear in their original positions and continue to move westward again. This migration pattern is known as westward drift (Hide *et al*., 1993; Backus *et al*., 1996). The South Atlantic feature at the CMB is quite intriguing because it overlaps with the SAA. This so-called anomaly is a large patch of weak magnetic field located in the South Atlantic whose origin and evolution are still debated (Moffatt, 1978; Backus *et al*., 1996). The South Atlantic feature in the velocity maps and SAA can be related as is pointed out by Hulot, et al., 2002. These authors arrived at such conclusion after they analyzed the data provided jointly by Magsat and Ørsted for the period over 1980-2000 (Hulot *et al*., 2002). Also, the westward drift of the SAA is well established, and its temporal evolution is studied extensively. There can be constructed various models aiming to

describe it, where one way is constructing a monopolar model at the CMB (De Santis and Qamili, 2010).

In this paper we have illustrated the new approach of using the Gauss's coefficients provided by the global model **gufm1** to construct at the CMB the velocity field of the fluid core relative to the fixed mantle. The reliability of the method is confirmed by the magnitude of the relative velocity which at it maximum is 20 km/yr and is in good agreement with the figures of previous studies. The maps are qualitatively different from their counterparts constructed by other authors. The reason lies in the fact that the velocity field calculated by the equations (12) is sensitive to the initial data and the technique employed for the inversion. The observation of the westward drift is crucial in confirming the reliability of the method. Also, the connection between features in the velocity field at the CMB and features of the geomagnetic field brings more evidence supporting the method used in the actual paper.

The use of a global model with such a long temporal coverage is very useful in jointly analyzing the SV of the radial geomagnetic field and the evolution of the fluid flow at the CMB. Also, it makes possible to study the relation between jerks and the change of the velocity field at the CMB by generating the maps of the velocity field at the CMB on monthly basis. The results of this study will be described in a forthcoming paper.

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GURI I TOPIT ZONE - AN INTERMEDIARY TECTONO-STRATIGRAPHIC UNIT BETWEEN THE EXTERNAL AND INTERNAL ALBANIDES

Shyqyri ALIAJ*

ABSTRACT

The Guri i Topit Flysch Zone is an intermediary tectono-stratigraphic unit between the Krasta and Mirdita zones, i.e., between the External and Internal Albanides. It could be correlated in the whole Dinaric-Albanian-Hellenic belt with Bosnian and Beotian flysch zones. The stratigraphic section of Guri i Topit Zone consists from bottom to top of rift related volcanics, the Middle-Upper Triassic to Early Jurassic pelagic limestones, the Middle-Upper Jurassic radiolarites and the ophiolite-bearing Tithonian-Valanginian Flysch. The Guri Topit flysch basin differentiated at the end of the Upper Jurassic time, where the ophiolite-bearing turbidite deposition started. In addition, it is developed as an intermediary basin located between the Krasta basin and Mirdita oceanic basin, from which the ophiolite-bearing debris derived. The side by side development of the Krasta, Guri Topit and Mirdita zones, the setting of the Guri i Topit flysch zone between the Krasta and the Mirdita zones and the flysch sequences deposited in the Krasta and Guri Topit zones conditioned by the sedimentary hiatuses in Mirdita zone reveal the location of Mirdita oceanic basin to the west of Korabi-West Pelagonian Zone. Two settings of Late Tithonian-Valanginian ophiolite-bearing flysch sequence in the Mirdita zone, as in the whole Dinaric-Albanian-Hellenic belt, are postulated: i) the Late Tithonian-Valanginian flysch sequence underlying the ophiolite nappe is part of the independent tectono-stratigraphic units (Bosnian, Guri i Topit and Beotian flysch zones) and, ii) the Late Tithonian-Valanginian flysch sequence overlying the ophiolite nappe (Maglaj in Serbia, Firza in Albania, Othris and Pelion area in Greece). The aforementioned types of Late Tithonian-Valanginian ophiolite-bearing flysch sequence could be considered as deposited during the main phases of Mirdita ophiolite obduction, related to the closure of the Mirdita oceanic Basin. The tectonic windows of Kruja and Krasta zones in the Peshkopia region (eastern Albania) were formed due to the Pliocene-Quaternary extensional tectonics accompanied by normal faulting and evaporite diapirism which created cupola pattern horsts and favoured the erosion of the Mirdita and Korabi upper nappe sheets. The latter could be observed only at the margins of these windows. The ophiolite bodies found along the normal faults at frontal part of Korabi Zone up to Korabi Highlands and along nappe boundaries surrounding the

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Krasta and Kruja tectonic windows could be regarded as they have been pulled up from the ophiolite massifs underlying the Korabi Zone.
Keywords: Guri i Topit Zone, stratigraphy and structure, two settings of Late Tithonian-Valanginian ophiolite-bearing Flysch sequence, evidences for the location of Mirdita oceanic Basin to the west of Korabi-West Pelagonian Zone

1. INTRODUCTION

Multidisciplinary researches about the geological and mineral resources of Gramshi region, Albania have been carried out by Çili *et al*., (1973). The detailed geological investigations involved the geologic mapping at the scale 1: 5.000 and some stratigraphic sections carried out in Guri i Topit area by Çili *et al*., (1974). These geologic field studies was summarized in (Aliaj and Gjata 1979). Later on, a stratigraphic section in the Guri i Topit mountain was carried out by Lula *et al*. (1979), verifying the lower part of Guri i Topit stratigraphic section. Some years later (1982-1984), the geological mapping at the scale 1:25.000 was carried out by Pulaj *et al*. (1985) in the Guri i Topit-Polis-Guri i Muzhaqit wide region, and by Marishta and Jupa (1985) in the Guri Topit-Lenie and Gramshi massif region. In the Mirdita Zone, Pulaj *et al*. (1985) distinguished two subzones: i) the ophiolite subzone and, ii) an other carbonate subzone outcropped with interruption in the shape of a very narrow belt from Uji Ftohtë to Shushica village near Elbasani.

These geological investigations provided better information about the geologic profile of Guri i Topit and the results have been reported in the geological maps of Albania at the scale 1:200.000 (1983 and 2005).

Guri i Topit sector was attributed to Mirdita Zone by some scholars (Biçoku *et al*., 1967; 1970; Shehu *et al*., 1983; Pulaj *et al*., 1985; 1990), and some others (Çili *et al*,. 1973, Aliaj and Gjata 1979; Lula *et al*. 1979; Meço and Aliaj 2000; Xhomo *et al*., 2002b) included it into the Krasta Zone.

Figure 1 depicts the setting of Guri i Topit zone consisting of a complete section from the Middle Triassic to the Tithonian-Berriasian-Valanginian Early Flysch. The Tithonian-Lower Cretaceous (Berriasian-Valanginian) early Flysch in Guri i Topit area marks the important tectonic compressive event that occurred in the Internal Albanides during the closing of Mirdita oceanic basin (Kodra *et al*., 2000; Xhomo *et al*., 2002b).

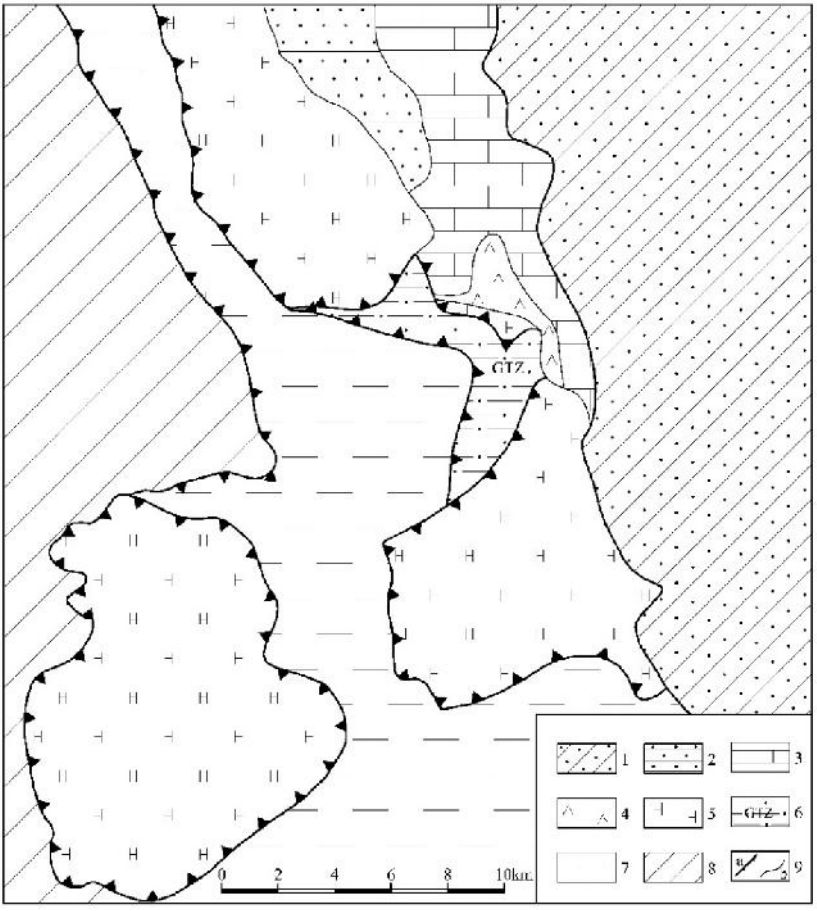

Fig. 1: Geologic Setting of Guri i Topit Zone1-Albanian-Thessalian Basin Middle Oligocene-Aquitanian deposits. Mirdita Zone: 2- Middle-Upper Eocene terrigenous deposits, 3- Lower Cretaceous mainly carbonates, 4- Middle Jurassic basic volcanics, 5- Middle Jurassic harzburgite massifs. 6- Guri i Topit Zone (GTZ), 7- Krasta Zone, 8- Kruja Zone, 9a- Nappe boundary, 9b- Stratigraphic contact.

The known Early flysch in Krasta Zone, Albania and Pindos Zone, Greece, has the same Albian-Cenomanian-Turonian age (Melo and Kanani 1978; Lula *et al*., 1979; Zuros and Mountrakis 1990; Xhomo *et al*., 2002b). Lula *et al*., (1979) and Meço and Aliaj (2000) pointed out that the stratigraphic succession from the Tithonian-Valanginian to the Albian-Cenomanian-Turonian flysch deposites misses in the Krasta Zone. Aliaj re-investigated the geological profile of Guri i Topit involved in the Ostreni Subzone of Krasta Zone (Aliaj and Kodra 2016) and conluded that the Guri i Topit geological profile proves that it could not be included neither in the

Krasta Zone nor in the Mirdita Zone, but it represents a completely new tectono-stratigraphic unit, named Guri i Topit Zone, taking place at the forehead of Mirdita Zone overthrust.

The Guri i Topit Zone takes place between the Krasta and Mirdita zones in the shape of a north-northeast extending narrow belt, from about 2-3 km to 8 km wide and 6-7 km long. It overthrusts Krasta Zone to the west. It overthrusts Krasta zone to the west and it is overthrust by Mirdita Zone from the east and north (Fig. 1).

The present paper is based on the author's observations carried out in Guri i Topit area in the years 1973 and 1974, especially on his field diary of the Guri Topit geological mapping at the scale 1: 5.000 and on different geologic mappings and studies carried out later on by Lula *et al*. (1979), Marishta and Jupa (1985) and Pulaj *et al*. (1985), especially on the Velçani i Mokrës Geologic Map at the scale 1:25.000 adapted by Pulaj (2005).

2. STRATIGRAPHIC PROFILE OF GURI I TOPIT ZONE

Different geological researches and studies have been carried out in the Guri i Topit area by Çili *et al*. (1973; 1974) and the results were summarized in the paper of Aliaj and Gjata (1979), by Lula *et al*. (1979), Marishta and Jupa 1985 and Pulaj *et al*., (1985) reporting that a complete stratigraphic section for Guri Topit Zone could be observed, although its geological structure has been cut by many normal faults (Fig. 2).

The stratigraphic section which occurs in Guri i Topit Zone consists from the bottom to the top of rift related volcanics, the Middle-Upper Triassic to Early Jurassic pelagic limestones with a chert parcel in between, the Middle-Upper Jurassic radiolarites with intercalations of thin-bedded black limestones with *Protopeneroplis striata*. Upwards continues the Upper Jurassic radiolarite-limestone intercalation with rare sandstone beds, including the ophiolite debris and, the Tithonian-Valanginian terrigene turbidites (Early Flysch) consisting of conglomerate-sandstone intercalations with ophiolite debris passing up to marly limestone-mudstone ones (Aliaj and Gjata 1979; Pulaj 2005).

The Guri i Topit Zone consists from bottom to top of these stratigraphic units: i) Middle Triassic extrusives, ii) Middle-Upper Triassic-Lower Jurassic pelagic limestones, iii) Middle-Upper Jurassic radiolarites and, iv) Upper Jurassic-Early Cretaceous (Tithonian-Berriasian-Valanginian) Early Flysch (Fig. 3).

Different researchers attributed these stratigraphic units to the different ages: the effusive rocks to Middle Triassic (Marishta and Jupa 1985), to Lower-Middle Triassic (Pulaj *et al*., 1985); the pelagic limestones to Middle Triassic-Lower Jurassic (Pulaj *et al*., 1985), to Upper Triassic-Lower Jurassic

(Lula *et al*. 1979, Marishta and Jupa 1985); the radiolarites to Middle Jurassic (Pulaj *et al*. 1985), to Upper Jurassic (Marishta and Jupa 1985), to Middle-Upper Jurassic (Lula *et al*. 1979) and, the early Flysch to Upper Jurassic (Tithonian)-Lower Cretaceous (Valanginian) (Marishta and Jupa 1985, Pulaj *et al*. 1985; Xhomo *et al*., 2002b; Pulaj 2005).

2.1 Middle Triassic Extrusives

The Middle Triassic extrusives, the oldest formations in the Guri i Topit area, underlay the pelagic limestones of Upper Triassic-Lower Jurassic age. A north-northeast extending volcanic block in the shape of a narrow belt could be met at Çuma Mountain. Farther northwards from Guri Topit to Uji Ftohtë they could be met in narrow belts represented by tectonic blocks, and in some places, as for example at Guri i Topit foots and Stream of Gurit etc., they are normally covered by the pelagic limestones of Middle-Upper Triassic-Lower Jurassic age.

The two relatively big outcrops, covered normally by Middle-Upper Triassic-Lower Jurassic spots, are located near the northern nappe boundary of Guri Topit Zone (Fig. 2).

The extrusive rocks are represented from bottom to top by two different extrusive formations: i) the Uji i Ftohtë basic volcanic formation and, ii) Guri i Topit intermediate-acid volcanic formation (Fig. 3).

The Uji i Ftohtë basic volcanic formation, about 50 m thick, is rich in spilites, microspilites, diabasic-plagioclasic porphyrites, and less microdiabases and albitic diabases with rare cherty and tuffogenous sandstone thin interbeds. The basic volvanic rocks have the massive texture consisting of spilitic-diabasic lavas with mainly spheric microtexture, into which the almond-oval shapes of 1-5 mm dimensions, and the microdiabasic and porphyric structure could be clearly distinguished.

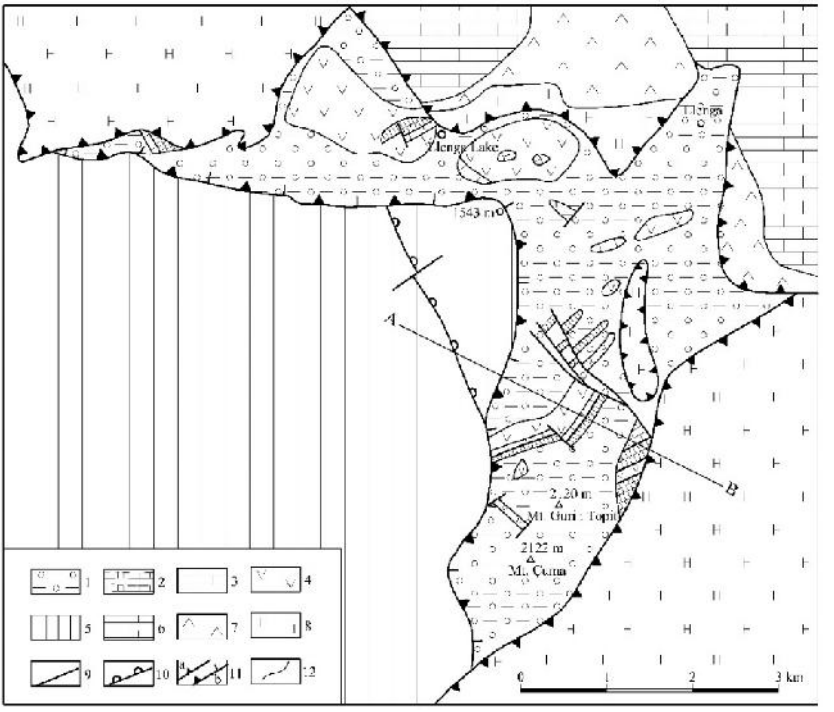

Fig. 2: Geologic Map of Guri i Topit Zone. 1-Tithonian-Valanginian Ophiolite-bearing Flysch Formation, 2- Middle-Upper Jurassic Radiolarite Formation, 3- Middle Triassic-Lower Jurassic Pelagic Limestone Formation, 4- Middle Triassic Extrusive Formation. 5- Krasta Zone. Mirdita Zone: 6- Lower Cretaceous mainly carbonates, 7- Middle Jurassic basic volcanics, 8- Middle Jurasisc harzburgite massifs. 9- Normal Fault, 10- Reverse Fault, 11a- Nappe boundary, 11b- Overthrust complicated by normal faulting, 12- Stratigraphic contact, A-B - Geologic cross-section line (Fig. 4).

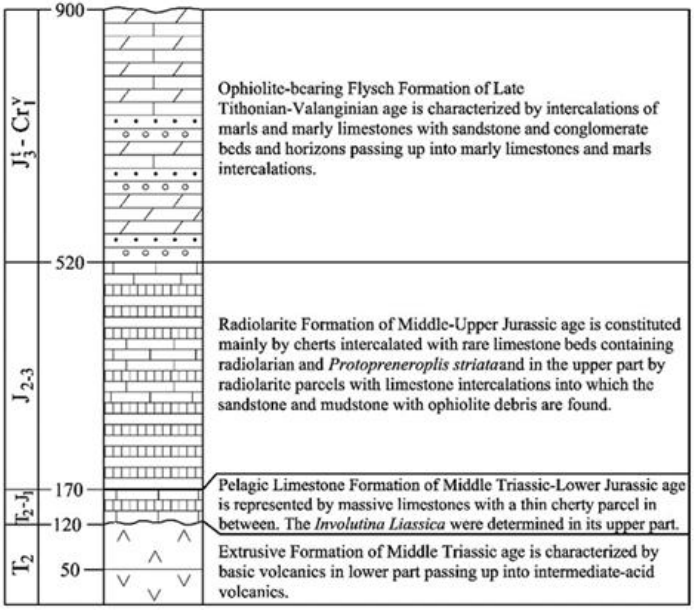

Fig. 3: Stratigraphic Column of Guri i Topit Zone.

The Guri i Topit intermediate-acid volcanic formation, about 70 m thick, overlays normally the Uji i Ftohtë basic volcanic formation. It consists of trachiandesites, trachiliparites and dacites with very rare cherty, tuffogenous sandstone and limestone thin interbeds. They have mainly massive texture, rarely the almod microtexture, and the porphyric, rarely glass, andesitic or trachiliparitic structure.

2.2 Middle-Upper Triassic-Lower Jurassic Pelagic Limestones

The Middle-Upper Triassic-Lower Jurassic pelagic limestones could be met in some places normally overlaying the extrusive rocks and in others in tectonic contact with other formations (Fig. 2). At Çuma mountain and Guri Topit mountain-Uji Ftohtë Stream area they could be met in the shape of narrow belts. The best known geologic section found at Guri i Topit shows from bottom to top the three following lithological limestone packets: i) Lower packet of grey massive limestones, ii) Middle packet of cherts with reddish limestone interbeds and, iii) Upper packet of grey massive limestones (Fig. 3)**.**

Lower packet of grey massive limestones, about 15 m thick, is represented by pelagic micritic and biomicritic limestones containing numerous pelagic bivalves, *Globochaete alpina*, radiolaria etc.

Middle packet of cherts with reddish limestone interbeds, about 2-3 m thick, consits of cherty thin beds with thin bedded to laminated pelagic micritic limestone interbeds containing radiolaria, lagenides (*Frondicularia sp*.) and echinodermate fragments.

Upper packet of grey massive limestones, about 30 m thick, consists of micritic and biomicritic limestones with numerous pelagic bivalves, crinoide fragments, ostracode, embrionale ammonite etc. Here, *Involutina liassica* dating the Middle Liassic Age was determined among the others has been (Aliaj and Gjata 1979).

2.3 Middle-Upper Jurassic Radiolarites

The radiolarites could be found mostly at the Çuma Mountain, and northwards at Guri i Topit Mountain - Uji i Ftohtë Stream area in the shape of a north-northeast extending tectonic blocks, limited by normal faults (Fig. 2).

The radiolarite sequence is constituted mainly by cherts intercalated with rare limestone beds and in the upper part by sandstone and mudstone inetercalations.

The Middle-Upper Jurassic radiolarites are represented from bottom to top by two lithological packets: i) cherty-radiolarite packet and, ii) radiolarite-limestone packet (Fig. 3).

The cherty-radiolarite packet, about 100 m thick with any rare tuffogenous interbeds overlying Liassic limestones, is characterized by thin bedded chert-radiolarites from 3-4 cm to 20-30 cm. The rare black brecciated limestones met in this packet are rich in radiolaria and *Protopeneroplis striata*.

The radiolarite-limestone packet, about 250 m thick, is characterized by radiolarite parcels with limestone intercalations. The grey thick bedded and massive limestones, containing the cherty concretions, are biomicritic, microbiomicritic, biopelitic and marly ones. The main part of this packet comprises radiolarites, into which the coarse-grained sandstones and mudstones with ophiolite debris are found in its upper part.

2.4 Late Tithonian-Valanginian Ophiolite-Bearing Early Flysch

Guri i Topit zone consists mainly of Early Flysch sediments which in some places, as for example at Guri Topit mountain overlay normally the radiolarite formation and in most of this zone cover the underlying formations (Fig. 2)

The early Flysch deposits are represented by two lithological packets from bottom to top: a) the marly-conglomerate packet, and b) limestone-marly packet (Fig. 3).

The marly-conglomerate packet is characterized by the intercalations of mid-bedded marls and marly limestones with sandstone and conglomerate beds and horizons with ophiolite debris. The slump levels are also present into it. The seen thickness is about 200 m.

The limestone-marly packet, about 180 thick, is characterized by the intercalations of thin and mid-bedded marly limestones and marls with clayey shales, rarely containing the ophiolite-bearing sandstone and koglomerate beds.

A stratigraphic section for the folded early flysch sediments has been carried out along the Guri stream and the presence of limestone-marly lithological upper packet was shown.

The micritic and biomicritic marly limestones and marls is rich in tintides such as *Tintinopsella carpathica, Calpionellopsis oblonga, C. simplex, Remaniella cadischiana, Calpionella elliptica and* radiolarian, *Globochaeta alpina* which date this flysch series the Berriasian-Valanginian Age.

The marly-sandstone early Flysch deposits met in the wide region of Guri i Muzhaqit- Guri i Topit along the frontal part of Carbonate subzone of Mirdita zone (Pulaj *et al*., 1985) and in the Guri i Topit area (Lula *et al*., 1979) date since the Upper Tithonian-Berriasian age based on the pelagic microfauna: *Calpionella alpina, C. elliptica, C. oblonga, Tintinopsella Carpathica* etc.

The Early flysch sequence could be met also around the Talle sector of Ophiolite subzone of Mirdita zone where a stratigraphic section was carried out by Pulaj *et al*., (1985). The flysch deposits are supposed to overlay the volcanics. The Talle stratigraphic section about 490 m thick consists of the limestone-marly flysch which is represented by intercalation of limestones, marly radiolaritic limestones, marls with turbidite limestones and sandstones reach with ophiolite debris. The Upper Tithonian-Berriasian age of these early flysch deposits was examined by the following microfauna complex*: Calpionella elliptica, C. alpina, Remaniella Cadischiana, Crassicollaria sp.* etc. The Barremian-Aptian terrigeneous-conglomerate deposits transgessivelly topped this early flysch sequence in the Talle-Zgallo area (Pulaj *et al*., 1985).

The Tithonian-Valanginian age of early flysch sequence of Guri i Topit area has been reflected in the geologic maps of Albania at the scale 1:200.000 (Shehu *et al*., 1983, Xhomo *et al*., 2002), the Velcani i Mokrës geologic map at the scale 1: 25.000 (Pulaj 2005), the geologic map of Guri i Topit-Kukur-Lenie and Gramshi massif at the scale 1:25.000 (Marishta and Jupa 1985), and the geologic map of Guri i Topit-Guri i Muzaqit at the scale 1:25.000 (Pulaj *et al*., 1985).

3. STRUCTURE OF GURI I TOPIT ZONE

The main tectono-sedimentary events recorded in the Krasta, Guri i Topit and Mirdita ophiolite zones allowed us to define the individualisation of Guri i Topit Flysch Zone as a tectono-stratigraphic unit underlying the Mirdita ophiolite nappe, corresponding to an original location of the turbidite succession in a basin located at the eastern border of Krasta (Pindos) Basin, having the same pre-Late Tithonian sedimentary basin development with it, but presenting a deeper separate basin (named Guri Topit Flysch Basin), limited with the Krasta Basin to the west and Mirdita oceanic basin to the east by syn-sedimentary normal faults.

The Guri i Topit Flysch Basin differentiated at the end of the Upper Jurassic time, when the ophiolite-bearing turbidite deposition started. It developed in a basin located between the Krasta Basin and the Mirdita oceanic Basin, from which the ophiolite-bearing debris derived.

The generally north trending Guri Topit Zone contacts westwards the Paleocene-Eocene flysch of Krasta Zone, whereas it is overthrust by the Vallamare ultramafic massif from the south-east and by the Shpati ultramafic massif from the north-west. The north-extended small ophiolite nappe consisting of ultramafic rocks overlies the early Cretaceous flysch nearby to the west of stream Madh (Fig. 2). The Guri i Topit Zone locates between the Krasta and Mirdita zones and has the shape of a north-northeast extending narrow belt, from 2-3 km to 8 km wide and 6-7 km long.

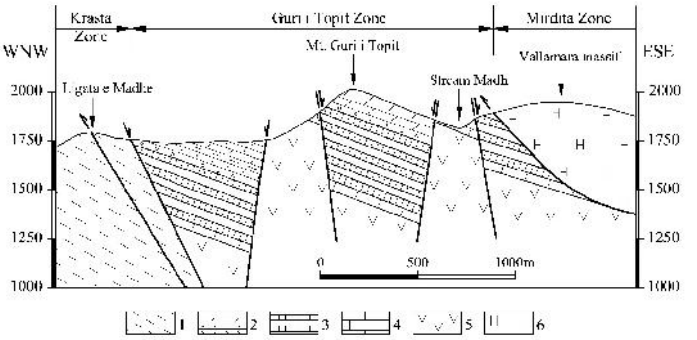

Fig. 4: Geologic Cross-section Ligata e Madhe-Guri i Topit Mountain-Valamara Massif1-Krasta Zone Palocene-Eocene deposits. Guri i Topit Zone: 2- Tithonian-Valanginian Ophiolite-bearing Flysch Formation, 3- Middle-Upper Jurassic Radolarite Formation, 4- Middle-Upper Triassic-Lower Jurassic Pelagic Limestone Formation, 5- Middle Triassic Extrusive Formation. 6-Mirdita Middle Jurassic harzburgite massifs. Legend is the same for figures 3, 5-8.

The Krasta Zone, thrusting the Kruja Zone-Tervolli anticline, extends along a belt from Zavalina in the north to Lenie Mountain in the south, always westward to the Mirdita Zone thrusting. It consists of Griba and Liseci assymetric crest anticlines.

The NNE extending Guri i Topit structure starts at Çuma Mountain and follows to Guri i Topit Mountain and further northwards. The complete section of Guri i Topit Zone encounters at the Guri i Topit mountain and along the watershed between the Gurit and Madh streams, whereas partial sections are found northwards up to nearby northern boundary of Guri i Topit Zone where two relativelly big effusive rock outcrops could be met. The early Flysch sequence takes the first main place in the surface of Guri i Topit Zone (Fig. 2).

The geological cross-section passing from the Ligata Madhe to Guri i Topit crest up to Vallamares ultrabasic massif shows: i) the geological structure of Guri i Topit zone representing a complete section cut by normal faults and, ii) the contact with the Paleocene-Eocene flysch deposits of Krasta zone through an overthrust complicated by normal faulting and it is overthrust by the Vallamares massif of Mirdita zone (Fig. 4).

Partial geological cross-section at Guri i Topit mountain shows that the Middle-Upper Jurassic radiolarites and Tithonian-Valanginian Flysch deposits bordered through normal faults with the Middle Triassic extrusive rocks-Middle Triassic-Lower Jurassic limestone succession in between (Fig. 5). The Figure 6 depicts the details of Guri i Topit geological structure overthrusting by the ophiolites of Vallamara massif to the east of Guri i Topit mountain.

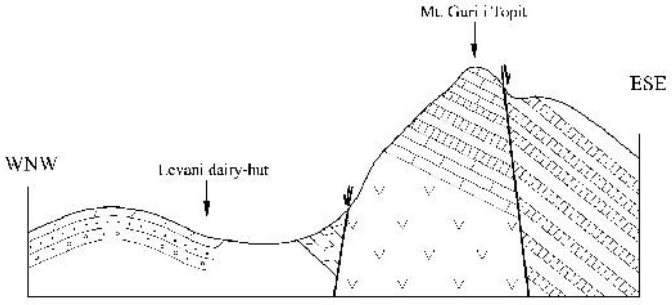

Fig. 5: Schematic Geologic Cross-section from Levani dairy-hut to Guri i Topit Mountain.

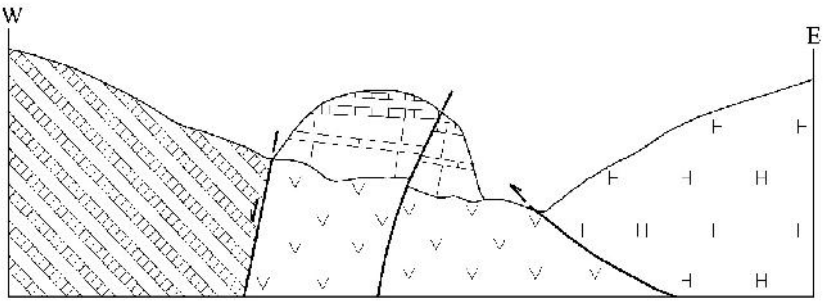

Fig. 6: Schematic Geologic Cross-section to the Eastern part of Guri i Topit Zone.

A complete section from the Middle Triassic extrusive rocks to Late Tithonian-Valanginian Flysch sequence cutting by normal faults is also observed passing the watershed between the Guri and Madhi streams (Fig. 7).

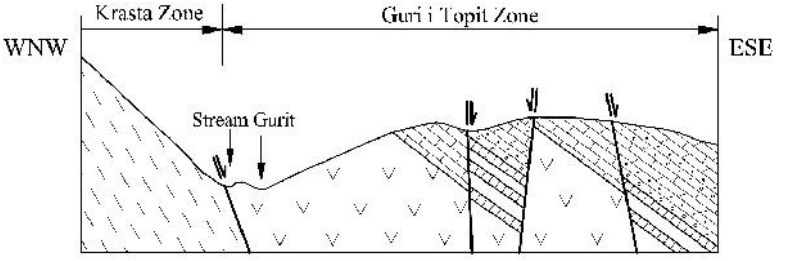

Fig. 7: Schematic Geologic Cross-section from Stream Gurit to ESE.

The generally north-extending overthrust complicated by normal faulting of Guri i Topit Zone starts in the south, about 700 m west of Çuma Mountain (2122 m) and follows to the west and nearby the height of 1967 m, further to about 650 m west of Guri Topit Mountain (2120 m) and 250 m west of Guri i Topit Lake. It follows northwards cutting the upper branches of Guri and Ujit Ftohtë streams up to the height 1543 m, where it, turning westwards, follows cutting heads of upper branches of Shulit stream and further to Gjaçit stream where it meets the overthrust of Mirdita Zone (Fig. 2).

The generally west trending Guri i Topit overthrust complicated by normal faulting completely covers main part of Griba anticline formations of Krasta Zone, whereas the Mirdita overthrust covers and hides from the north and east the continuation of Guri i Topit Zone (Fig. 2). The Upper Tithonian-Valanginian Flysch sequence limited through a normal fault from the Barremian-Aptian terrigenous-carbonate deposits down displaced nearby the stream Gurit extends from the Llenga village to Llenga Rock (Fig. 8).

The structure of Guri i Topit Zone have been cut by many high-angle normal faults. Some east-southeast extending transversal faults, and some other north-northeast extending longitudinal faults created the small horst-graben structures.

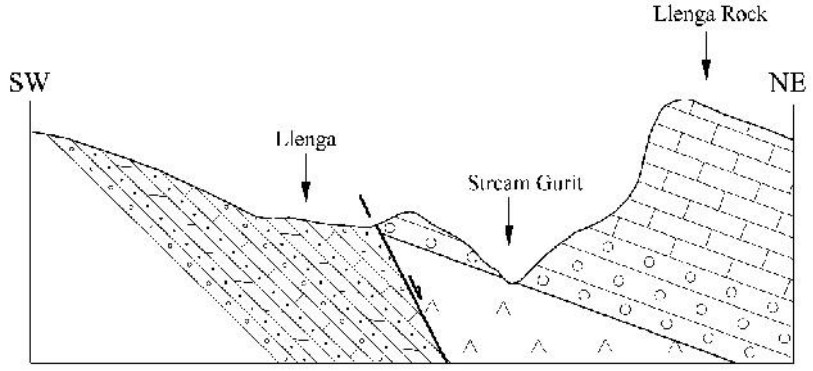

Fig. 8: Schematic Geologic Cross-section from Llenga Village to Llenga Rock

4 TWO DIFFERENT SETTINGS OF LATE TITHONIAN-VALANGINIAN OPHIOLITE-BEARING FLYSCH SEQUENCE IN THE MIRDITA ZONE

The settings of Late Tithonian-Valanginian Flysch sequence were reported in many locations of Mirdita Zone. The ophiolite-bearing Tithonian-Valanginian Flysch sequence overlying ophiolites could be met in northern Mirdita Zone in Firza, Rreshen, Derven, Munelle, Shëngjin, Kurbnesh, Guri Bardhë (Linos), Bizë, Ostren etc. in northern Mirdita Zone and, in Leskovik, Shtike, Kagjinas-Novoselë, Polenë, Talle, Shpelle, Babje, Gur Shpat etc., in southern Mirdita Zone (Xhomo *et al*., 2002b).

The ophiolite-bearing Tithonian-Valanginian Flysch sequence in Guri i Topit sector underlays the Mirdita ophiolites (Aliaj and Gjata 1979) taking part in the Guri i Topit Zone.

The ophiolite-bearing Tithonian-Valanginian flysch sequence determined by Calpionellids was found in Firza village, in the west of Rubik (Hajnaj and Aliaj 1975). The marly-conglomerate Tithonian-Valanginian early Flysch in Firza village is found in the shape of a north-northwest trending belt, about 8 km long, from Rubiku village in the north following to Firza village up to the Fangu village in the south, underlying the Mirdita ophiolites and Upper Triassic-Jurassic formations to the west of Rubiku, and overthrusting the Maastichtian flysch deposits of Krasta zone (Hajnaj and Aliaj 1975). Later on, the Tithonian-Valanginian early flysch deposits were found in the Guri i Topit

sector (Aliaj and Gjata, 1979) and, in Firza and Fang villages, to the west of Rreshen-Derven area (Shallo *et al*., 1983).

The Guri i Topit Zone consists mainly of Upper Tithonian-Valanginian ophiolite-bearing Flysch deposits. At the Guri Topit mountain they overlay normally the radiolarite formation, and in the main part of this zone they cover the underlying formations. The stratigraphic section which occurs in Guri i Topit Flysch Zone consists from the bottom to the top of: i) rift related volcanics, ii) the Middle-Upper Triassic to Early Jurassic pelagic limestones with a chert parcel in between and, iii) the Middle-Upper Jurassic radiolarites with intercalations of thin-bedded black limestones with *Protopeneroplis striata*. Upwards continues the Upper Jurassic radiolarite-limestone intercalation with rare sandstone beds, including the ophiolite debris and, iv) the Tithonian-Valanginian terrigene turbidites (Early Flysch) consisting of conglomerate-sandstone intercalations with ophiolite debris passing up to marly limestone-mudstone ones (Aliaj and Gjata 1979).

In addition, the early flysch sequence could be met around the Talla sector of Ophiolite subzone of Mirdita zone, to the north of Guri i Topit Zone, where a stratigraphic section was carried out by Pulaj *et al*., (1985). The flysch deposits there are supposed to overlay the volcanics. The Talla stratigraphic section, about 490 m thick, consists of the limestone-marly flysch which is represented by intercalation of limestones, marly radiolaritic limestones, marls with turbidite limestones and sandstones reach with ophiolite debris. The Upper Tithonian-Berriasian age of these early flysch deposits was examined by the following microfauna complex*: Calpionella elliptica, C. alpina, Remaniella Cadischiana, Crassicollaria sp.* etc. The Barremian-Aptian terrigeneous-conglomerate deposits transgessivelly topped this early flysch sequence in the Talle-Zgallo area (Pulaj *et al*., 1985).

The biostratigraphic work for the upper Tithonian-Valanginian flysch sequence dealt with Calpinollid findings from Rreshen-Derveni outcrops of Mirdita zone is reported by Gjata, Mustafa and Pirdeni (1989) The Upper Jurassic-Lower Cretaceous early flysch sediments transgressivelly overlay thin “clayey packet with pieces”, which covers the andesite-basalts of Mirdita zone. The early Flysch deposits were met in the outcrops at the Pergegaj area, Rreshen and at Lumthi stream etc., represented by conglomerates in the base, then by the intercalation of sandstones, marls, marly limestones and clayey-silty shales. A reach microfauna complex found in marls and marly limestones shows the following biozones: Crassicollaria, Calpionella and Calpionellites.

Shallo (1990) reported that ophiolite mélange and Tithonian-Early Cretaceous conglomerate-sandstone-marly flysch deposits with abudant ophiolitic detritus are widespread in the Eastern Albania, overlying transgressivelly or normally on top of ophiolite sequence through radiolarian

cherts of Kimeridgian-Tithonian age, or on the top of carbonate sequence of the periphery of ophiolites.

The litho- and biostratigraphic investigation of Firza flysch, the ophiolite Mirdita nappe, based on calcareous nannofosils, has been carried out by Gardin et al. (1996). Firza flysch with Simoni (Mirdita) mélange represents the sedimentary sequence overlying the Albanian ophiolites. The Firza flysch by them was subdivide in three members: the lower member (Perlati and Derveni sections) characterized by the prevalence of ophiolite-derived pebbly sandstones and mudstones, whereas the middle (Derveni section) and upper (Firza section) members show calcareous and mixed composition turbidites. In the Perlati and Derveni sections the Firza flysch stratigraphically overlies the Simoni mélange. In the Firza section, the flysch sequence occurs as a slice into the Rubik complex (Gardin *et al*., 1996).

The Simoni mélange and Firza flysch represented by thick sedimentary sequence unconformably overlying the Cherts on both the Western and Eastern Ophiolite Belts of Mirdita region can be regarded as syn-emplacement deposits, sedimented after the inception of ophiolite deformation. The Simoni mélange unconformably overlies the cherts or directly the pillow-lava and massive basalts. It is a typical “blocs in matrix-type” mélange which passes upwards in the Firza flysch. The Simoni mélange sedimentation probably occurred in a time span ranging from Late Oxfordian to Tithonian. The stratigraphical transition to the Firza Flysch, as well as the sedimentation features, corresponding to a high sedimentation rate, suggest a Tithonian age (Bortolotti *et al*., 2004). The Simoni mélange shows a gradual transition to the Firza Flysch, a turbidite deposit dated as uppermost Tithonian-Late Valanginian by Calpionellids and nannofossils assemblages (Gardin *et al*., 1996). The Firza Flysch is mainly characterized by the occurrence of ophiolite-bearing polimictic pebbly sandstones and mudstones at different stratigraphic levels. The succession concerns the Barremian conglomerate passing upwards to Albian-Aptian shallow-waters carbonates. The Barremian-Senonian sequence unconformably overlies the ophiolite sequence from peridotite to volcanics in the eastern belt of Mirdita region, whereas they are absent in its western belt. The final emplacement of the ophiolites in Albania is marked by the unconformable sedimentation of the Barremian deposits at the top of the ophiolite nappe. The Barremian age of these deposits confirms that the final emplacement of the ophiolites in Albania was ultimated in the Early Cretacous time and from the Late Cretaceous onwards the convergence mainly affected the continental margin (Bortolotti *et al*., 2004).

Peza (2007) reported about the Upper Jurassic and Neocomian deposits stratigraphy in the Mirdita Zone. The stratigraphic sections of Tithonian-Valanginian flysch deposits were carried out in many locations of Mirdita

ophiolite zone such as in the Derveni, Munella, Shenjti, Kurbneshi, Linos etc. The flysch deposits of Tithonian-Valanginian age in the Munella, Shenjti and Kurbneshi sections are unconformably topped by transgressive Barremian-Aptian neritic terrigeneous-carbonate deposits, whereas in the Derveni section they are uncovered.

Kodra *et al*., (1995; 2000) emphasised that the sandstone-marly "Firza" Flysch of Upper Tithonian-Valanginian age, met in the Firza village, to the west of Rubik, unconformably overlies the formations of Rubiku complex (i.e. the Upper Triassic-Lower Jurassic limestones, "blocs in matrix" mélange, volcano-sedimentary and brecciated serpentinite formations). The term "Firza Flysch", proposed by Gardin *et a1*., (1996), is now used for all the overlying ophiolites the Upper Jurassic-Lower Cretaceous early flysch deposits found in the Mirdita Zone (Xhomo *et al*., 2002b - Monography "Geology og Albania").

All the Tithonian-Valanginian Flysch deposits overlying the Mirdita ophiolites (named "Firza Flysch") can be correlated with the lower part of Maglaj sequence (Blanchet *et al*., 1970), which overlies the ophiolites of Serbian Zone. This sequence is assigned to late Tithonian-Berriasian by Capionellids. The Maglaj sequence is overlained by a clastic, pelagic sequence of Albian-Cenomaian age. Ferriere (1982) stated that late Tithonian-Berriasian, ophiolite-bearing turbidite sequence overlies the ophiolites in the Othris and Pelion area, Greece.

The Guri i Topit Flysch Zone could be correlated with the Bosnian flysch zone, previously described by Blanchet *et al*., (1969). This flysch outcrops in the north-south trending belt running from Bosnia to Montenegro and Albania (Vermoshi Zone). It is generally sansdwiched between the Late Cretaceous-Paleocene flysch and the ophiolite nappe, which has been correlated with the Mirdita ophiolite nappe of Albania.

Southwards, the Guri i Topit flysch zone could be correlated with the Beotian Flysch Zone (Celet *et al*., 1976; Clement 1976; Aubouin *et al*., 1977; Capedri *et al*., 1985; Nirta *et al*., 2015) which outcrops in Greece (Koziakas Mountain, north of Sperchios transform, and Iti, Parnasse, Beotian and Geranees Mountain areas south of Sperchios transform). The Beotian flysch sometimes associated to sedimentary melanges, is generally recognized as tectonic slice underlying the ophiolite nappe (subPelagonian zone).

In the Mirdita Zone, as in the whole Dinaric-Albanian-Hellenic Belt, the ophiolite-bearing turbidite deposits of Upper Tithonian-Valanginian age could be detected in two different geological settings: i) in the first one, the Late Tithonian-Valanginian Flysch sequence overlying the ophiolite nappe (Maglaj in Serbia, Firza in Albania, Othris and Pelion area in Greece) and, ii) in the second one, the Late Tithonian-Valanginian Flysch sequence underlying the ophiolite nappe takes part in the independent tectono-stratigraphic units

(Bosnian, Guri i Topit and Beotian Flysch zones). Marroni *et al*., (2009) concluded that in the whole Dinaric-Hellenic belt, two settings of the origin of ophiolite-bearing flysch basins are postulated: a foredeep basin, that developed since Late Jurassic up to Early Cretaceous on the continental margin, and a thrust-top-basin located over an advancing ophiolite nappe.

5 DISCUSSION

The Guri i Topit geological building confirms that it could not be included neither in the Krasta Zone nor in the Mirdita Zone, but it represents a completely new tectono-stratigraphic unit, named Guri i Topit Zone. The Guri i Topit Flysch Zone is an intermediary tectono-stratigraphic unit between the Krasta and the Mirdita zones, i.e. between the External and Internal Albanides. It could be correlated in the whole Dinaric-Albanian-Hellenic Belt with Bosnian and Beotian Flysch zones.

The stratigraphic section of Guri i Topit Zone is consists from bottom to the top of rift-related volcanics, the Middle-Upper Triassic to Early Jurassic Pelagic limestones, the Middle-Upper Jurassic radiolarites and the Tithonian-Valanginian terrigeneous turbidites (Early Flysch) consisting of conglomerate-sandstone intercalations with ophiolite debris (Aliaj and Gjata 1979).

Geological data in the Krasta, Guri Topit and Mirdita zones contribute to the reconstruction of their tectonic and sedimentary evolution. contribute to the reconstruction of their tectonic and sedimentary evolution. The reconstructed evolution of the Guri Topit Flysch Zone is compared with main events recorded in the Krasta Zone to the west and, the Mirdita Zone to the east.

Stratigraphic data reported that the Krasta Zone could be subdivided into the two following subzones (Aliaj and Kodra 2016): i) Lisen-Spiteni Subzone represented by a succession of the Middle Triassic volcanics, Middle-Upper Triassic-Jurassic limestones, Upper Jurassic radiolarites and Cretaceous limestones, overlaid by Paleocene-Middle Eocene flysch, and ii) Derja Subzone consisting of the Albian-Cenomanian-Turonian Flysch, Late Cretaceous limestones and the Upper Maastrichtian-Late Eocene Flysch (Xhomo *et al*., 2002b).

The southward continuation of the Krasta zone in Greece is followed by the Pindos zone. It consists of Mesozoic carbonate and siliciclastic rocks and the Tertiary flysch (Aubouin 1959; Fleury 1980). The first Pindos flysch formation dates the Albian-Turonian. Different thrusting planes have been distinguished along the thrust front of the Pindos nappe. Along the Metsovitikos River, a major transverse fault zone, known as Kastaniotikos fault interrupts the continuation of the Pindos zone. The carbonate series of

the Pindos zone do not appear to the north of this fault where only the Tertiary Pindos flysch represents the Pindos nappe and overthrust the Ionian flysch of the Zagori basin (Zouros and Mountrakis 1990).

Based on the aforementioned data on the stratigraphic succession of Krasta Zone in Albania and Pindos Zone in Greece, it could be concluded that the Guri Topit Zone stratigraphic section from Middle Triassic to Upper Jurassic age, besides local differentiations, is correlatable with that of Pindos zone to the south of Kastaniotikos transversal (mainly limestones of Middle Triassic-Liassic age and the radiolarites of Early Dogger-Tithonian age), and with that of Krasta Lisen-Spiteni subzone.

The Guri Topit succession ended upwards with the Late Tithonian-Lower Cretaceous (Berriasian-Valanginan) terrigeneous turbidites (Early Flysch). The ophiolite-bearing Flysch deposits dating the Upper Tithonan-Valaginian age in Guri Topit section (Guri Topit Zone) normally cover the radolarite formation dating the Middle-Upper Jurassic age.

The Guri Topit Flysch basin differentiated at the end of the Upper Jurassic time, where the ophiolite-bearing turbidite deposition started. In addition, it is developed in a basin located between the Krasta Basin and the Mirdita oceanic Basin, from which the ophiolite-bearing debris derived.

The ophiolite-bearing Tithonian-Valanginian Flysch overlying ophiolites could be seen in Firza, Rreshen, Derven, Munellë, Shëngjin, Kurbnesh, Guri Bardhë (Linos), Bizë, Ostren etc. in the northern Mirdita zone, and in Leskovik, Shtikë, Kagjinas-Novoselë, Polenë, Talle, Shpellë, Babje, Gur Shpat etc. in the southern Mirdita Zone (Xhomo *et al*., 2002b).

The ophiolite-bearing Tithonian-Valanginian flysch deposits underlie the Mirdita ophiolites in the Guri i Topit sector (Aliaj and Gjata 1979).

The Barremian-Senonian sequence unconformably overlies the ophiolite sequence from ultramafites to volcanics in the Eastern Belt of Mirdita region, whereas they are absent in its Western Belt. In some sectors of southtern Mirdita zone, the Senonian limestones overlie transgressively the ophiolites (ultramafites) through the Fe-Ni ore deposits in the Eastern Ophiolitic Belt, whereas the Lower Cretaceous (Barremian-Aptian) deposits unconformably overlay the ophiolites in the Western Ophiolitic Belt (Xhomo *et al*., 2002b).

In Polis and Bërzeshtë sections of the Western Belt of southern Mirdita Zone, the Barremian-Aptian deposits overlying the ophiolites, through a bauxite ore level are overlaid by neritic Senonian limestones, whereas in Xhumage section, through iron-nickel ore deposits covering the ultramafic rocks of Middle Jurassic age overlay the Barremian-Aptian limestones, which in turn are overlaid by Senonian biomicritic limestones. In the Librazhd-Prrenjas-Pogradec areas of the Eastern Belt of southern Mirdita Zone as in Bushtricë, Prrenjas, Çervenake and Guri Kuq, the Senonian biomicritic

limestones through the iron-nickel ore deposits overlay directly the ophiolites (Xhomo *et al*., 2002b).

The Barremian deposits unconformably overlying the ophiolites in Albania confirms that the final emplacement of the ophiolites in Albania was ultimated in the Early Cretacous time and from the Late Cretaceous onwards the convergence mainly affected the continental margin (Bortolotti *et al*., 2004).

The above-marked different syn- and post-emplacement ophiolite development of Northern Mirdita segment from that of Southern Mirdita one point out the Elbasan-Diber transversal dividing them, which has been a second order transform fault in the Mirdita oceanic basin (Xhomo *et al*., 2002b).

The model involving the presence of Mirdita oceanic basin between the Guri Topit and Korabi tectono-stratigraphic units explains also that the Late Tithonian-Valanginian Guri Topit Flysch sequence would have sedimented during the westward obduction of the Mirdita ophiolites.

The setting of Guri Topit Zone (Beotian zone in Koziakas area) between the Krasta (Pindos) Zone and Mirdita (sub-Pelagonian) Zone can shed light on the existence in the Jurassic times of Mirdita ocean basin located to the west of Korabi/West Pelagonian Zone.

The Pelagonian Zone can be divided into two tectono-stratigraphic units: the Korabi-West Pelagonian Zone and East Pelagonian Zone. The East Pelagonian Zone is regarded as an exhumed Pelagonian dome (Lower Pelagonian unit) beneath the overthrust of Korabi-West Pelagonian Zone (Upper Pelagonian unit) (Kilias *et al*., 2010).

The boundary between the Mirdita and Korabi zones can be drawn after the contact of ultrabasic massifs of Mirdita Zone with the Triassic-Jurassic limestones of the Korabi Zone (Papa 1971; Aliaj 1991; 1993; Aliaj and Meço 1994; Meço and Aliaj 2000).

Nopcsa pointed out that tectonic relations among the zones in Northern Albania are of nappe (allochtonous) character, with the exeption of the boundary between the Mirdita and Korabi zones. Mirdita Nappe delimits with Korabi Zone through a great fault called by Nopcsa “Drini Fault”. Nopcsa presented the Mirdita Nappe as an ophiolite pre-Gosaw nappe and that the origin of Mirdita Nappe should be further investigated—to the east, about 90 km in Prizren (Nopcsa 1929). Zuber (1940) has underlined that “the Albanian ophiolite nappe” underlies the Shar-Dag (=Korabi) Zone.

Kodra (2016, in Aliaj and Kodra 2016) considered the Mirdita Zone as a super-structure zone consisting of Hajmeli and Qerret-Miliska subzones in the western periphery of ophiolites, and the Gjallica and Mbasdeja subzones in its eastern periphery. The Mirdita oceanic Basin has been the generation place of the Albanian ophiolites (Xhomo *et al*., 2002a).

The present paper does not aim at discussing or analyzing in details the paleogeographic setting and the evolution of Mirdita oceanic Basin. However, some data testifying that the Mirdita ophiolites underlie the Triassic-Jurassic carbonates and Silurian-Devonian deposits of Korabi/West Pelagonian Zone (Aliaj 1991; 1993; Aliaj and Meço 1994; Qirinxhi *et al*., 1991) are briefly introduced. The data about the Kruja and Krasta tectonic windows within Korabi Zone is a means to address the paleogeographic location of Mirdita ophiolite Zone.

The Kruja and Krasta tectonic windows observed in Peshkopia region were formed due to the Pliocene-Quaternary extensional tectonics, accompanied with normal faulting and evaporite diapirism, which created cupola pattern horsts and favoured the erosion of the Mirdita and Korabi upper nappe sheets. The latter could be observed only at the margins of these windows (Aliaj 1993).

Many small ophiolite (mainly serpentinite) bodies are found more than 25 km to the east of Lura and Bulqiza ultramafic massifs from the frontal part of Korabi Zone (Selishte, Lan-Lure, Draj-Reç and Resk) up to Korabi Highland (Stanet e Preshit, Avdanicë, Fusha e Panaireve, Piramida 2 and Tejs), and to the surroundings of the Mali Bardhë, Peshkopi and Dibra e Madhe evaporite dome tectonic windows (Kalle, Vleshe, Dipjake, Trojak, Shumbat, Renz, Vrenjt, Veleshice River, Biçaja pass, Skertec, and Kosovrasti) (Melo 1966; Petkovski 1979; Gjata *et al*., 1984; Xhomo *et al*., 1991; Qirinxhi *et al*., 1991; Aliaj 1991; 1993; Aliaj and Meço 1994; Hoxha 2001; Xhomo *et al*., 2002b).

The ophiolite bodies found along the normal faults at frontal part of Korabi Zone and along nappe boundaries surrounding the Krasta and Kruja tectonic windows could be considered as they have been pulled up from the Mirdita ophiolite massifs underlying the Korabi Zone. Qirinxhi *et al*., (1991) pointed out that the Korabi nappe overlays Mirdita ophiolites (serpentinites) covered by Late Jurassic-Early Cretaceous flysch in Veleshica river.

The ophiolite (serpentinite) outcrops (injections) in the Triassic limestones to the east of ultramafic massifs were considered as the pre-ophiolitic synrift magmatism (Godroli *et al*., 1991; Kodra and Bushati 1991).

The east verging typical nappe structures of the Korabi Zone Triassic-Jurassic deposits overlying the Mirdita ophiolites at the frontal part of Korabi Zone are observed in the sector from Selishta to Resk in an up to 8-10 km wide belt. They represent west-ward plunging synform anticlines and antiform synclines (Melo 1985; Aliaj 1991; 1993) developed in a retrocharriage manner showing the W to E displacement of rock masses due to the strong barrier of Cretaceous basal conglomerates and neritic limestones, transgressively overlaying the ophiolites. To the east of Korabi Zone east verging cascad of nappe structures, the kink small folding observed in S-D

schist and sandstone deposits at Muhurri bridge passing the Drini i Zi River show the E-W displacement of rock masses. The above given data testify the end Cretaceous Korabi nappe setting over the Mirdita ophiolites covered by Tithonian-Valanginian flysch deposits can be regarded as the direct testimony for the location of Mirdita oceanic Basin to the west of Korabi-West Pelagonian Zone.

CONCLUSIONS

The here presented data from the Krasta, Guri Topit and Mirdita tectonic units allowed us to define important points in the reconstruction of the common tectono-sedimentary evolution of the above-mentions units developed side by side. The following conclusions could be drawn:

1. The Guri i Topit Flysch Zone is an intermediary tectono-stratigraphic unit between the Krasta and the Mirdita zones, i.e. between the External and Internal Albanides. It can be correlated in the whole Dinaric-Albanian-Hellenic Belt with Bosnian and Beotian Flysch zones. The individualisation of Guri Topit Flysch Zone as an intermediary tectono-stratigraphic unit underlying the Mirdita ophiolite nappe, corresponds to an original location of the turbidite succession in a basin located to the east of Krasta Basin, having the same pre-Late Tithonian sedimentary basin development with it, but presenting a deeper separate basin (named Guri Topit Flysch Basin), limited by syn-sedimentary normal faults with the Krasta Basin to the west and Mirdita Ocean Basin to the east. The Guri i Topit Flysch Basin differentiated at the end of the Upper Jurassic time, where the ophiolite-bearing turbidite deposition started; it is developed in a basin located between the Krasta basin and the Mirdita oceanic basin, from which the ophiolite-bearing debris derived.

2. The ophiolite-bearing flysch deposits could be considered as deposited during the Late Tithonian-Valanginian time in the subsiding Guri Topit Basin during the main phases of Mirdita ophiolite obduction. These deposits represent the marker of the Late Tithonian-Early Cretaceous phases related to the closure of the Mirdita Oceanic Basin. The major hiatuses in the section of Mirdita zone in Southern Albania had an impact on the deposits of flysch sequences in the Guri Topit and Krasta zones as follows: a) The ophiolite-bearing Late Tithonian-Valanginian Flysch sequence in the Guri Topit Flysch Basin can be regarded as a syn-emplacement deposits, sedimented after the inception of the ophiolite obduction from the nearby Mirdita oceanic Basin, b) the Albian-Turonian first flysch sequence, consisting of clastic material, including the ophiolite debris, found in the Krasta Zone section, has been deposited during the major sedimentary hiatus between the Barremian-Aptian overlying the ophiolites and the Senonian

sequence of Western Ophiolitic Belt of southern Mirdita zone and, c) the Upper Maastrichtian-Late Eocene flysch sequence in the Krasta zone section has been deposited during the end-Cretaceous-Eocene post-emplacement of Mirdita Zone.

3. The side by side development of Krasta, Guri Topit and Mirdita zones, the setting of Guri Topit Flysch Zone (Beotian Zone in Koziakas Greece) between the Krasta (Pindos) Zone and the Mirdita (sub-Pelagonian) Zone and the deposition of flysch sequences in the Krasta and Guri Topit zones conditioned by the sedimentary hiatuses in Mirdita Zone point out the location of Mirdita Oceanic Basin to the west of Korabi-West Pelagonian Zone.

4. The tectonic windows of Kruja and Krasta zones in the region of Peshkopi (eastern Albania), formed due to the Pliocene-Quaternary extensional tectonics, accompanied by normal faulting and evaporite diapirism which created cupola pattern horsts and favoured the erosion of the Mirdita and Korabi upper nappe sheets, which are seen only at the margins of these windows. The ophiolite bodies found along the normal faults at frontal part of Korabi Zone up to Korabi Highland and along nappe boundaries surrounding the Krasta and Kruja tectonic windows can be regarded as they have been pulled up from the Mirdita ophiolite massifs underlying the Korabi Zone. The above-mentioned data show that Mirdita ophiolites underlie the Korabi nappe structures; they are a good testimony to the location of Mirdita oceanic Basin to the west of Korabi/West Pelagonian Zone.

5. The east verging typical nappe structures composed of Triassic-Jurassic deposits overlying the Mirdita ophiolites at the frontal part of Korabi Zone are evidenced in the sector from Selishta to Resk in an up to 8-10 km wide belt. They present west-ward plunging synform anticlines and antiform synclines developed in a retrocharriage manner showing the displacement from W to E of rock masses due to the strong barrier of Cretaceous basal conglomerates and neritic limestones transgressively overlying the ophiolites. To the east of Korabi east verging cascad of nappe structures, the kink small folding observed in S-D schist and sandstone deposits at Muhurri bridge passing the Drini i Zi River shows the E-W displacement of rock masses. The above given data showing the end Cretaceous Korabi nappe setting over the Mirdita ophiolites covered by Tithonian-Valanginian flysch can be regarded as the direct testimony for the location of Mirdita oceanic Basin to the west of Korabi-West Pelagonian Zone.

6. Two settings of Late Tithonian-Valanginian ophiolite-bearing Flysch sequence in the Mirdita Zone, as in the whole Dinaric-Albanian-Hellenic Belt, are postulated: a) the Late Tithonian-Valanginian Flysch sequence underlying the ophiolite nappe takes part in the independent tectono-stratigraphic units (Bosnian, Guri i Topit and Beotian Flysch zones) and, b) the Late Tithonian-

Valanginian Flysch sequence overlying the ophiolite nappe (Maglaj in Serbia, Firza in Albania, Othris and Pelion area in Greece). These two settings of Late Tithonian-Valanginian ophiolite-bearing flysch sequence can be regarded as deposited during the main phases of Mirdita ophiolite obduction, related to the closure of the Mirdita oceanic Basin.

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GEOTECHNICAL CHARACTERIZATION OF HILLY TERRAIN IN TIRANA URBAN AREA

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ABSTRACT

Geotechnical investigation has been carried out in the hills of Tirana, Albania from 2000 to 2015 for design and construction purposes and the results are here reported. The hilly area has an east-south-west extension and a complicated morphology, with slopes angle ranging from 5-15^{o} to 35-45^{o}. Geotechnically, it consists of weak rocks, most of which are covered by soils. Soils have low to medium values of the physical-mechanical properties. Samples were collected for laboratory testing, in addition to in situ tests and boreholes drilled. The results reported that behavior and properties of soils and rocks depend on their content, formation processes and environmental conditions throughout their geological history. In addition, they have been of great impact to the planning and development of Tirana urban area. In the end, some conclusions and recommendations are given to avoid, prevent, or substantially mitigate the hazard.

Keywords: geotechnical properties, hilly terrain, slopes, weathering crust, soils, weak rocks, physical-mechanical properties, lithology, geomorphology, hydrogeology, slope stability

1. INTRODUCTION

The area here investigated has an east-south- west extension and has been subject of many engineering geological and geotechnical investigation for urban planning and urban development purposes (Muceku and Lamaj

2005; 2009). Demographic movement of 1990-2000 was of great impact to geodynamic phenomena uncontrolled constructions. Muceku and Lamaj (2005; 2009) and Muceku (2006) carried out geological and geotechnical investigation to address the problems. Consequently, engineering geological map at the scale 1:10 000 and engineering geological map at the scale 1: 25000 were compiled for the urban and suburban area of Tirana, due to uncontrolled constructions. In addition, engineering geological investigation at a more detailed scale was unavoidable. The 1:2000 to 1:1000 scales have been useful in the geotechnical morphological analysis of soils and rocks' properties, hydrogeological and mass movement analysis of 2005-2009. Consequently, foundations sites were properly defined, and the engineering objects were prevented from geodynamic phenomena. Data about geological, lithological, geomorphological, hydrogeological and geotechnical properties of the Tirana region are here reported.

1. MATERIALS AND METHODS

Engineering geological mappings at scale 1:10000 and 1: 25000 have been compiled (Muceku and Lamaj 2005; 2009) and data about the morphology, lithology and mass movements distribution in Tirana region were collected from 2000 to 2008. Soil samples were collected for physical-mechanical properties' laboratory testing and soil classification was carried out based on lithological, geomorphological and hydrogeological content, mass movements and weathering crust. The geotechnical investigations of 2008-2015 were carried out for the design and construction of two-four story residential structures. Boreholes (7.0-10.0 to 12.0m) were drilled and pits (3.5-5.0m) were dug. In addition, Electrical Resistance Tomography (ERT) and Standard Penetration Test (SPT) were applied and many soils and rocks samples were collected at different depths. Grain size (sieve and hydrometer tests ASTM D 422), Atterberg limits (ASTM D 4318), bulk density (ASTM D 2435), specific density (ASTM D 854), natural water content (ASTM D 2216), elastic module parameters (confined compress test ASTM D 2435), strengths parameters (shearing box-internal friction angle, c, cohesion, ASTM D 3080) and uniaxial resistant compress under natural conditions were analyzed for the physical and mechanical properties. The limit equilibrium software, Slide 6.037, Rocscience, 2015 was involved for the slope stability. In the end, detailed geotechnical data were obtained.

2. RESULTS AND DISCUSSION

The data obtained from engineering-geological mappings at the scale 1:10000 and 1: 25000 and geotechnical investigations have been very helpful

for the civil engineering. The geotechnical profile of the area investigated and the geological factors that cause mass movement are in the forthcoming paragraph discussed.

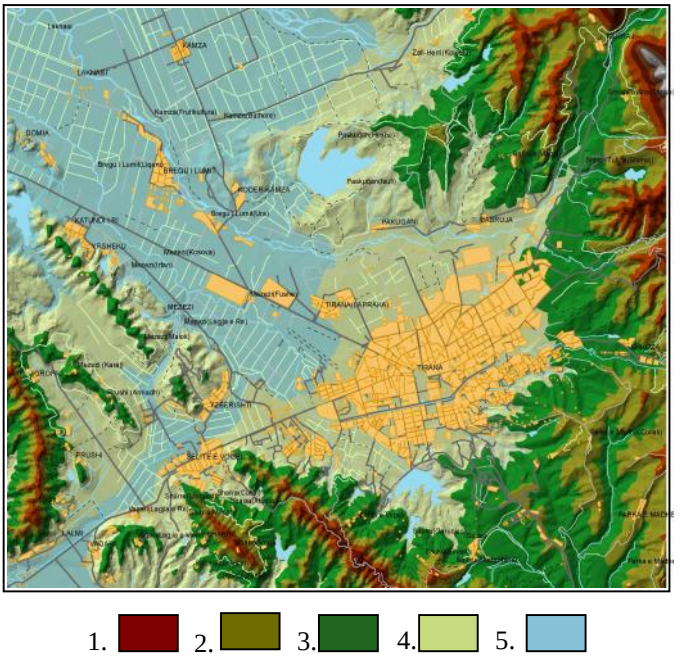
Geomorphology

The investigated area is geomorphologically part of the hill's morphologic unit and its inclination angle varies from gentle (6^o - 15^o) to very steep (> 45^o). Figure 1 depicts the geographic position of Tirana (Muceku, 2006).

The hills in the east consist of two parallel ranges running north-south-Lundër-Farka-Shkozë-Babru-Paskuqan-Instituti Bujqësor and Shish Tufinë-Linzë-Surrel hills. The first one starts directly in the east of Tirana depression and is represented by small hills raning from 50.0-100.0m to 150.0-200.0m. The Shish Tufinë-Linzë-Surrel hills chain extends in the east of these hills. Its altitude ranges from 150.0-200.0 to 350.0m. and the hills slope angle from 9-12^o to 45^o in Kashari hills.

The hills in the south are represented by the Selita-Picalla-Sauku hills (Fig. 1) and have a northwest - southeast extension and the altitude ranges from 150.0-230.0m (Selita) to 300.0-376.0m (Picalla). The angle of the hills slopes ranges from 10-25^o up to 50^o. Investigations reported that in some places the hill slopes are affected by the landslides and erosion. Consequently, gullies and channels have been created.

The western hills are represented by the Yzberishti-Yrsheku-Domja and Kombinati-Kashari-Bërxulli hills (Fig. 1) and consist of two parallel ranges running north -south. Their altitude ranges from 90.0m-180.0m up to 207m (Karaj). Failure events occurred in the area which represented concave - convex slopes in the upper faces and convex slopes in the lower faces. Generally, the slope angle ranges from 6^o to 20^o in Yzberisht hills and from 20^o to 35^o-45^o in Kashari hills. These natural hills' slopes show the rock mass quality, rocks weathering grade, mass movement, erosion and deposition process. The upper parts of slopes are remnants shapes caused by landslides. Occurred in former time, erosion phenomena have a steep angle. In the middle-lower parts of the hill's slopes, the angle becomes gentle, due to the soils deposition that are formed by the occurrence of landslides and erosion processes. The hill's morphologic unit consists of molasses rocks-claystones and siltstones layers intercalated with sandstones layers.



1. 2. 3. 4. 5.

Fig. 1: Morphometric map of Tirana urban area.1. Hill's morphologic unit with altitude >250m, 2. hill morphologic unit with altitude 200-250m, 3. hill morphologic unit with altitude 150-200m, 4. hill morphologic unit with altitude 100-150m, 5. flat morphologic with altitude < 100.

Mass movement

Many buildings have been damaged due to active landslides. Geomorphology, lithological formations, geological structure, geotechnical properties of bedrocks and soils, precipitation events and anthropogenic activity are the main sources for mass movement and its distribution (Muceku and Lamaj 2005, 2009; Muceku and Krutja 2002; Muceku and Reçi 2008; Frasheri 2017), reported that the area is subject to mass movements and erosion phenomena because it is characterized by very weak and weak rocks with low geotechnical parameters. Depicted in the Figure 2 and 3, Cruden and Varnes (1996) said that earth flow and earth slides are two types of mass movement. They generally occur on the slopes of the hills with angle that ranges from 12^{o} to 35^{o}. The earth flows are from 30.0–50.0m up to 75.0–100.0m long, 10.0–50.0m wide and 1.8–2.5m to 3.5–4.0m deep. Earth slides are from 20.0–40.0m to 50.0–80.0m long, 50.0–100.0m wide and 3.5–5.0m to 6.0–8.0m deep (Fig. 2 and 3). Muceku and Korini (2014) and Muceku *et al*., (2013; 2016) reported that heavy rain days trigger mass movements.

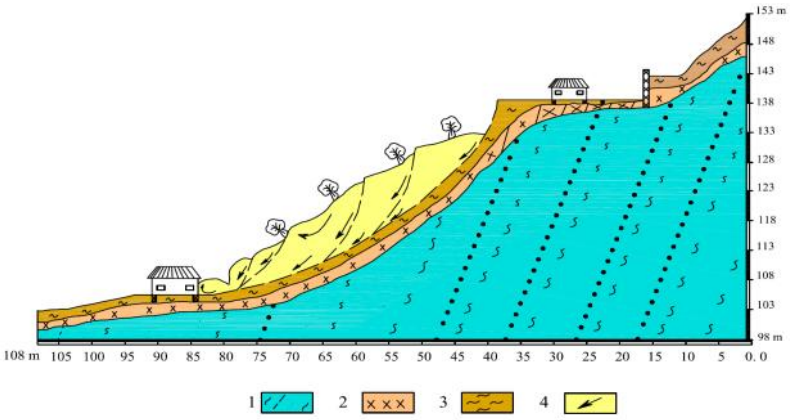


Fig. 2: Lithological cross section of hill slope, in studied area. 1-Very weak rocks, claystones-siltstones, 2- weathering crust of the claystones-siltstones rocks, 3- inorganic silts and very fine sands, silty fine sands and inorganic clays of low to medium plasticity (ML-CL), 4-landslide body.

Geology

The area is rich mostly in molasses formations of Upper Miocene (N_1^3) and less in Quaternary deposits. The latter, are represented by the diluvium soils, which are from 1.5-2.5m to 4.0-6.0m thick and consist of silts, sandy clays and silty and silty fine sands (Muceku and Lamaj, 2005; 2009).

Structurally, molasses formation could be met in the folded structure of Tirana syncline. Muceku and Lamaj (2005; 2009) said that geologically, the rocks could be classified as following: i) Mëzezi geological unit with an east - west extension and consisting of intercalated claystones and siltstones layers, ii) Iba geological unit rich in sandstones deposits that outcrop in east and west of the Mëzezi geological unit, iii) Skuterra geological unit located in the east and west of the Iba geological unit and is represented intercalated claystones and siltstones layers and, iv) Priska geological unit situated in the east and west of Tirana syncline and consisting of conglomerate and sandstones rocks. In the east, it consists of limestones rocks.

Hydrogeology

Muceku and Lamaj (2005; 2009) said that the area consists hidrogeologically of two rock complexes: i) intercalated claystones and siltstones layers complex and, ii) sandstones complex belonging to the aquiclude group and the aquifer group, respectively, based on the hydrogeological characteristics. Sandstones deposits could be classified into poor to medium aquifer based on their water bearing capacity. Field works

reported that during the rainy season could be met at a depth from 1.0m up to 3.5m and in the dry season it could be met from 10.0 to 12.0m.

Geotechnical characterization of hill slopes

Geotechnical condition

From the geomorphologic point of view the studied area is included in the hill's morphologic unit. It has an inclination angel 6^o - 15^o (gentle), 16^o - 25^o (moderately gentle), 26^o - 35^o (moderately steep), 36^o - 45^o (steep > 45^o (very steep). Based on the geographic position in relation to the city of Tirana, it is classified in the eastern, southern and western hills.

Both engineering-geological mappings at the scale 1:10000 and 1:25000 and geotechnical investigations reported several geotechnical units with different physical-mechanical properties (Muceku and Lamaj 2005; 2009) as reported in the table 1 and 2 and depicted in the figures 3 and 4:

The geotechnical unit no. 1 consists of inorganic silts and very fine sands and silty fine sands soils (ML) (Samtani and Nowatzki, 2006). They are beige, brown and grey in color with hard consistency and from 3.5-4.5m up to 7.0m thick. Most of the hill slopes consist of these soils.

The geotechnical unit no. 1* is represented by inorganic silts and very fine sands, silty fine sands and inorganic clays of low to medium plasticity (ML-CL) (Samtani and Nowatzki, 2006), brown and grey in color. These soils have stiff to very stiff consistency and are generally 2.0-3.5m up to 5.0m thick.

The geotechnical unit no. 1** consists of inorganic clays of low to medium plasticity (CL), brown and grey in, color stiff to medium consistency (Samtani and Nowatzki, 2006) and, from 1.5-3.0m up to 4.5m thick. The present soils are found on lake slopes and rivers.

The geotechnical unit no. 2 is represented by weathering crust (completely up to medium weathered rocks) of the combination of claystones with siltstones layers and sandstones rocks. These formations vary from very hard soils to very weak rocks based on the physical mechanical properties (Romana, 1996).

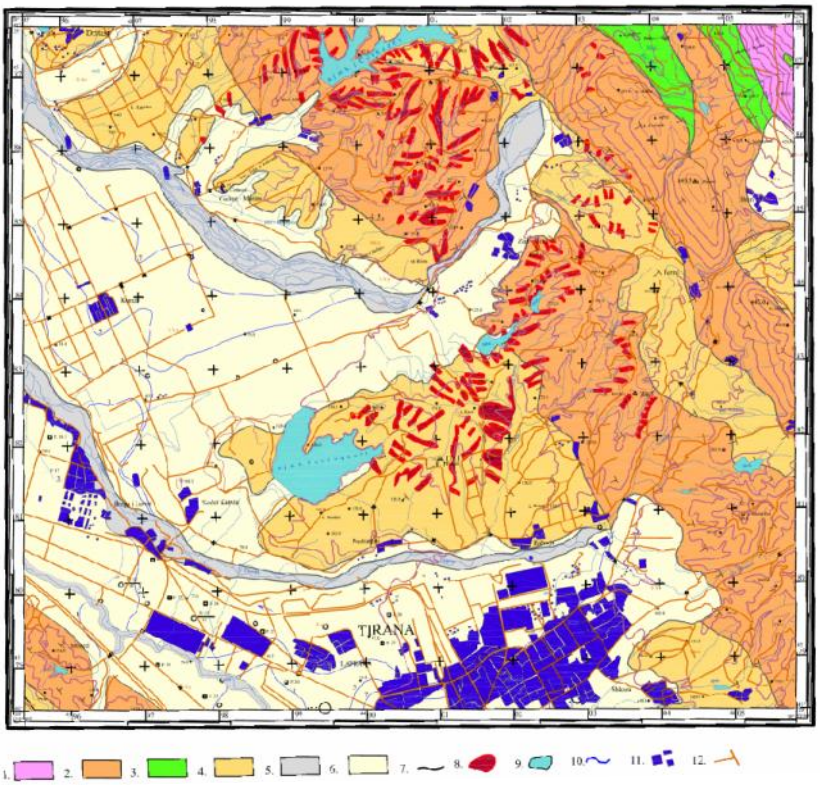


Fig. 3. Geotechnical map of Tirana urban area, scale 1:10000 1. Limestones-hard rocks, 2. sandstones-weak rocks, 3. combination of claystones-siltstones layers with and stones-medium strength rocks, 4. very weak rocks, claystones-siltstones. 5. gravels, 6- norganic silts and very fine sands, silty fine sands and inorganic clays of low to medium plasticity, 7. lithological boundary, 8. landslide, 9. lake, 10. river, 11. Tirana urban area, 12. geological structural elements.

The geotechnical unit no. 3 consists of very weak rocks (Romana, 1996) characterized by the combination of claystones with siltstones layers grey in color with the weak rocks (Romana, 1996) which consist of grey sandstones. The bedrocks consist of the combination of claystones with siltstones layers and sandstones. Soils overlay the bedrocks. Generally, these rocks decomposed into soils by climate features (precipitation, wind), i.e., the weathering processes (dissolving-graying or iron rusting-reddening). Once decomposed, the rocks physical-mechanical properties changes. Consequently, that there is a significant reduction of geotechnical properties on top of these rocks (1.5-2.0m to 3.5-5.0m deep). Table 2 reports that the geotechnical properties of these rocks have decreased more than one half of

their values (geotechnical unit no. 2). Overtime, these formations turned into more homogeneous soils i.e., residual soils, products of chemical weathering and thus their characteristics are dependent upon environmental factors of climate, parent material, topography and drainage, and age and deluvial soils found in the lower parts of the slopes.

Laboratory testing and in- situ testing reported that these soils mostly consist of inorganic silts and very fine sands, silty fine sands and inorganic clays with low to medium plasticity (ML-CL) and stiff to hard consistency. In addition, they have brown and grey color and thickness ranging from 2.5-3.5m to 5.0-6.0m.

Geotechnical properties of soils under the earth surface have from low-medium to high values and the underground water table varies from 0.0m to 1.5m (during rainfall seasons) to 10.0-12.0m (dry season).

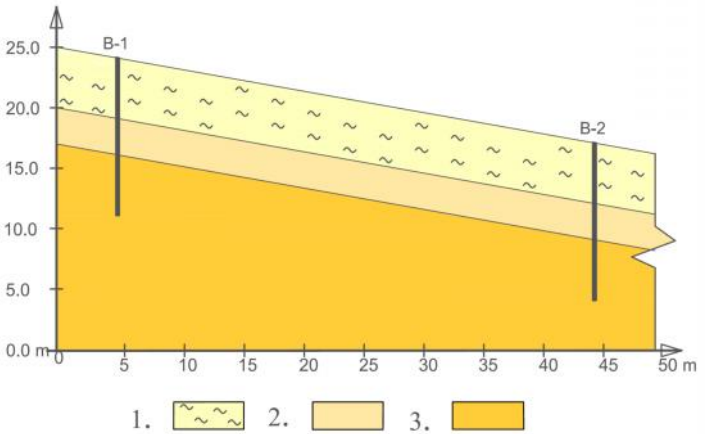


Fig. 4. Lithological cross section of hill slope, in studied area 1- Inorganic silts and very fine sands, silty fine sands and inorganic clays of low to medium plasticity (ML-CL), brown and grey color, 2- weathering crust of the claystones-siltstones rocks, 3-very weak rocks, claystones-siltstones.

Table 1. Geotechnical properties of hills slopes soils

Geotechnical unit nr.	Wn	γ	γ_o	φ	c	E	υ	Soils
	(%)	kN/m³	kN/m³	(o)	kPa	MPa		
1	19.8-21.6	19.4-19.8	26.8-27.0	20-23	37.3-44.13	13.3-20.3	0.31	ML
1*	23.1-25.9	19.1-19.2	26.9-27.1	15-16	19.7-24.5	6.2-9.8	0.33	ML &CL
1**	28.7-30.2	18.6-18.8	27.0-27.0	12-14	9.8-14.7	3.7-5.6	0.35	CL

W_n - natural water content, γ-bulk density, γ_o-specific density, φ - internal friction angle, c -cohesion, E- elastics module, υ-poisson ratio, ML &CL – soils types

Table 2. Geotechnical properties of rocks

Geotechnical unit nr.	Wn	γ	γ_o	φ	c	E	σ	υ	Rocks
	(%)	kN/m^3	kN/m^3	(o)	Mpa	MPa	MPa		
2	11.99-16.72	20.50-21.99	26.0-26.5	24-28	0.065-0.152	25.8-74.7	1.24-2.76	0.26-0.30	Weathering Crust Mo
3	0.41-3.90	22.9-23.8	26.7-27.3	28-30	40.4-47.8	170-980	3.04-6.74	0.23-0.27	Mo

W_n - natural water content, γ-bulk density, γ_o-specific density, φ - internal friction angle, c -cohesion, E- elastics module, σ-uniaxial compress strength, υ-Poisson ratio, Mo - molasses rocks

Geotechnical features of hill slopes

The area consists mostly of combination of weak rock and claystones-siltstones and less of weak rock-sandstones. These rocks decomposed into soils by water absorption. Once the rocks decomposed, the geotechnical properties decreased. Consequently, the weathering crust (1.8-3.5m to 5.0-7.0m thick) has been created in the upper part of the lithological profile (Muceku and Lamaj 2005; 2009). It has lower geotechnical properties compared to parents' material. Thus, the decomposition of rocks is dependent upon environmental factors of climate. In addition, the hilly slopes are mainly covered by soils (ML and CL), which generally are from 3.5-5.0m to 7.0m

thick. Under dry weather conditions the soils have good geotechnical properties and rainfall reduces their geotechnical properties (Muceku and Lamaj 2005; 2009).

Slope stability analysis

The slope stability of the hills was evaluated using the limit equilibrium software Slide 6.037, Rocscience, 2015 (Fig. 5). The physical mechanical parameters used in this model for each geotechnical unit are the internal cohesion (c), friction angle (φ), bulk density (γ), depth of underground water table, thickness of the geotechnical unit, slope angle and soils' thickness. The PGA hazard values obtained from the Albanian seismicity map (Duni and Kuka, 2008) and both rain and seismic activity map (Muceku and Korini 2014; Muceku *et al*., 2013; 2016) were involved for the stability analysis to investigate the parameters. In addition, the urban area is much affected by rainfall which range annually from 1600 to 1800mm (Themelko and Mustaqi, 1996). The safety factor was calculated based on geotechnical, geomorphologic, climatic-rainfall and seismic conditions (Muceku and Korini, 2014, Muceku *et al*., 2013;2016). Based on safety factor "S_F" computation, the slope is considered safe only if S_F >1.3. We have critical values if $1.0 \leq S_F \leq 1.3$ and unstable values if S_F <1.0 map (Muceku and Korini 2014). Slope stability data (Fig. 5) reported that the geotechnical unit no. 1 (ML), 1*(ML-CL), and 1** (CL), are subject to mass movements.

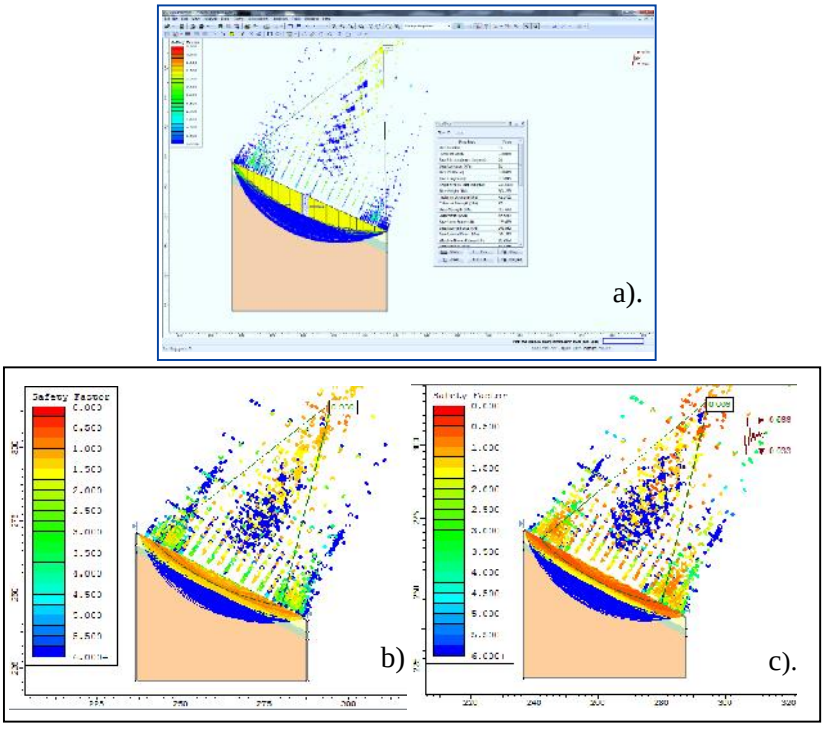


Fig. 5. Model of safety factor computed by finite element of hill slope, in studied area a). Limit equilibrium software Slide 6.037, Rocscience, 2015, b). in the case of wet, c) in the case of wet and PGA

Table 1 and Fig. 4 report the *Geotechnical unit no.1*. Here, the safety factor "S_F" data for all the slope angles reported that the slopes are stable under dry weather conditions, as $S_F \geq 1.43$. The safety factor "S_F" data reported that if PGA=0.27 and slope angle $\alpha \leq 30^o$, the slopes are stable under the same climatic conditions because $S_F \geq 1.36$ and for slopes angle α = 30-40^o, slopes are found in critical state ($1.02 \leq SF \leq 1.13$). In saturated conditions (rainy days), the calculated safety factor "S_F" point out that slopes are in a stable state for slopes angle $\alpha \leq 30^o$ ($S_F \geq 1.46$). In rainy days and PGA=0.27, the slopes areas are stable for slopes angle $\alpha \leq 20^o$ ($S_F \geq 1.36$), in critical state for slopes angle α = 25-30^o ($1.24 \geq S_F \geq 1.01$) and unstable state for slopes angle $\alpha \geq 25^o$ ($S_F \leq 0.94$).

If in the *Geotechnical unit no.1** the slope angle $\alpha \leq 25^o$ under dry climatic conditions, the slopes are stable because $S_F \geq 1.33$. If slope angle α = 26 ^{o} -30^o, the slopes are found in critical state ($1.03 \leq S_F \leq 1.23$). If slopes' angle is $\alpha > 30^o$, the slopes are unstable because $SF \leq 0.9$. If under dry climate conditions the hill slopes angle $\alpha \leq 15^o$ and PGA=0.27, the slopes are found

stable because $S_F \geq 1.35$. If slopes' angle $\alpha > 20^o$, the slopes are unstable, because $SF \leq 0.84$. In rainy days, the computed safety factor "S_F" highlight that slopes are in a stable state for slopes angle $\leq 15\text{-}17^o$ ($S_F \geq 1.36$). While, in case of rainy days and PGA=0.27, the slopes areas are stable for slopes angle $\alpha \leq 10^o$ ($S_F \geq 1.30$), in critical state for slopes angle $\alpha = 10\text{-}12^o$ ($1.08 \geq S_F \geq 1.0$) and unstable state for slopes angle $\alpha > 12^o$ ($S_F \leq 0.83$).

If in the *Geotechnical unit no.1*** the slope $\leq 15^o$ under dry climate conditions, the slopes are stable because $S_F \geq 1.31$. If under the same climatic conditions slope angle $\alpha = 15\text{-}17$, the slopes are in critical state ($1.00 \leq S_F \leq 1.18$). If slope angle $\alpha > 17^o$, the slopes are unstable because $SF \leq 0.85$. The safety factor "S_F" computed for the hill slopes $\alpha \leq 10^o$ in case of dry days seasons and PGA=0.27 point out that the slopes are stable because $S_F \geq 1.32$ and for slopes $>10^o$ they are unstable because $SF \leq 0.83$. While, the safety factor "S_F" calculated for the slopes $\alpha \leq 6\text{-}7^o$ in case of rainy days and PGA=0.27 shows that the slopes are stable ($S_F \geq 1.3$), while for slope angle exceeds 8^o the slopes are unstable because ($S_F \leq 0.77$).

In all the cases, consolidation of the foundation of unweathered rocks would be necessary. Slab foundation type may be used to avoid the differential settlements of engineering objects and to prevent engineering objects (buildings, traffic routes, etc.) from mass movement.

3. CONCLUSION AND RECOMMENDATIONS

The following conclusions could be drawn, and recommendations made: i) the hills of Tirana have an east-south-west extension and a complicated morphology, with slopes angle ranging from $5\text{-}15^o$ to $35\text{-}45^o$, ii) geotechnically, it consists of very weak rocks to weak rocks (claystones-siltstones and sandstones), ii) the upper part consists lithologically, of claystones-siltstones and sandstones rocks being represented by weathering crust (completely up to medium weathered rocks), which range from 1.8-2.5m to 3.5-5.0m, iv) the hills slopes which are covered by the soils have good geotechnical properties, except for some areas where the hills slopes are of medium qualities, v) the bed rocks decomposes into soils by climate features (precipitation, wind), i.e., the weathering processes (dissolving-graying or iron rusting-reddening), vi) under dry climatic conditions, the hills slopes are found stable, under wet climatic conditions, most of hills slopes are found stable for slopes angle $\alpha \leq 30^o$, vii) under the same climatic conditions and PGA=0.27, the slopes areas are stable for angle $\alpha \leq 20^o$ viii) a solid foundation on the rocks would be unavoidable and, ix) slab foundation type would be appropriate for the differential settlements of engineering objects and mass movement.

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IDENTIFICATION OF CYP2C19*2 ALLELIC VARIANT IN HEALTHY ALBANIAN POPULATION

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ABSTRACT

CYP2C19O, one of the genes involved in drug metabolism, is a member of cytochrome oxidase P450 family enzymes. It is involved in the metabolism of many clinically important drugs, such as omeprazole, clopidogrel, mephenytoin, diazepam, citaloparam, imipramine, amitriptyline and clomipramine etc. Some allelic variants, which modify the enzymatic activity are found in human populations, as CYP2C19*2 and CYP2C19*3. CYP2C19*2 allele, is a poor metabolizer allele and was found in Balkan region at various frequencies from 8 to 16%. In the present study, for the identification of CYP2C19*2 allele we applied a PCR-RFLP protocol, based on DNA amplification (PCR) and digestion by restriction enzyme SmaI. We analysed the DNA, from a group of 68 healthy Albanians, randomly selected. 57.4% of them resulted homozygous for allele CYP2C19*1, 41.2% heterozygous for allele CYP2C19*1 and CYP2C19*2 and 1.47% homozygous for CYP2C19*2 allele. The frequency of wild type allele CYP2C19*1 was found to be 77.9% while the frequency of CYP2C19*2 allele was found to be 22.1%. These results suggested a particular pattern of CYP2C19*1 and *2 alleles where the frequency of CYP2C19*2 allele is the highest found in European populations. About 4.9% of Albanians are poor metabolizers for substrates of CYPC19 enzyme and about 34% are intermediate metabolizers, which should be taken in consideration by clinicians when determining the drug dosage of their patients based on CYP2C19 genotype.
Keywords: Albanian population, allele, CYP2C19, genotype, polymorphism

1. INTRODUCTION

Cytochrome P450 enzymes (CYP450 enzymes) are a superfamily of hem-proteins which apart from endogenous compounds (Shimada *et al*., 1994) they metabolize about 75% of the prescription drugs in use (Ingelman 2004). There

is an association between CYP 450 based genetic variation and the outcome of drug therapy, adverse drug reactions and therapeutic failures. Changes to amino acid sequence of these enzymes can alter both enzymatic activity and substrate specificity (Azarpira *et al*., 2010). These variants cause drugs to be metabolized either faster or slower than normal. As a result, some individuals have trouble inactivating a drug and eliminating it from their bodies, leading to systemic overexposure to the drug, while others eliminate the drug too rapidly before it has had a chance to work (Karczewski *et al*., 2012). For these reason different patients responds differently to the same dose and the same medication.

CYP2C19 enzyme is part of CYP450 family enzymes. It metabolizes a number of drugs with narrow therapeutic index, including the antiplatelet drug clopidogrel, the antiulcer drug omeprazole, the anticonvulsant mephenytoin, the antimalarial drug proguanil, the anxiolytic drug diazepam, and certain antidepressants such as citalopram, imipramine, amitriptyline, and clomipramine etc. (De Morais *et al*., 1994; Lee, 2013). Highest expressions of the enzyme are generally found in liver tissue (Preissner *et al*., 2013).

Enzyme CYP2C19 is composed of 490 amino acids. It metabolizes 10% of most commonly prescribed drugs in use today. CYP2C19 enzyme is encoded by CYP2C19 gene which has 9 exons and it is located on chromosome 10 at position 23.33 (10q23.33). This gene is highly polymorphic. There are 35 genetic variants of CYP2C19 gene which are catalogued in the Human CYP Allele Nomenclature Database.

The most common loss-of-function variant is CYP2C19*2, which contains a 681G>A variant in exon 5 that results in an aberrant splice site. This leads to the production of a truncated and non-functional protein (Scott *et al*., 2012). The phenotype of CYP2C19 metabolic capacity can be categorized based on genotypes and includes: “Intermediate metabolizers” (IM) which are carriers of one copy of an allele that encodes reduced or absent function (CYP2C19*1/*2), “poor metabolizers” (PM) which are homozygous two loss-of-function alleles (CYP2C19*2/*2) and extensive metabolizers (EM) which are homozygous for the wild-type (wt) allele (CYP2C19*1/*1) (Klotz *et al*., 2004).

CYP2C19*2/*2 genotypes are responsible for the majority of PM phenotypes in the metabolism of CYP2C19 substrate drugs. The poor metabolizer phenotype which is inherited as an autosomal recessive trait represent 3-5% of Caucasians (Goldstein and de Morais 1994; Goldstein, 2001).

Frequency of allelic variants CYP2C19*1 (WT) and CYP2C19*2 are characteristic for each ethnic population. CYP2C19*2 allele is found among Caucasians at a frequency 8-16% and is significantly more frequent in East Asian populations (14-39%) and Africans (18-25%) (Shin *et al*., 2012).

The present paper aims at determining the CYP2C9*2 allele frequency and the percentage of individuals in Albanian healthy population who are carrier of CYP2C19 enzyme that metabolize more slowly the corresponding drugs as it is of crucial importance for the patients who might experience adverse drug reactions because of these polymorphisms. Identification of these alleles in Albanian population represent new genetic data that complete the pattern of frequencies for CYP2C19*1 and CYP2C19*2 variant in Balkan region.

2. MATERIALS AND METHODS

2.1 Sample size

We have analysed 68 healthy Albanian subjects randomly selected from different regions of Albania. Mean ±SD age was 37±14.48 years. To perform the analysis, we took 5 ml venous blood from each subject in K3 EDTA tubes.

2.2 DNA extraction

DNA blood kit (Qiagen, Hilden, Germany) and Invitrogen (DNA extracting mini preparation kit) were used following the manufacturer's instructions to extract DNA. The presence and quantity of DNA was confirmed by running in 1% agarose gel. DNA samples were stored in -20ºC until analysis was performed.

2.3 Genotyping procedure with PCR-RFLP method

The identification of CYP2C19*1 and CYP2C19*2 alleles in our sample was carried out applying the PCR-RFLP protocol as described in (Moraist *et al*., 1994; Sviri *et al*., 1999). We have done some modifications in the conditions of PCR amplification based on our laboratory protocols.

PCR

The 169 bp fragment on exon 5 that contained the CYP2C19*2 mutation (681G>A), was amplified by using two specific primers as in (Moraist *et al*., 1994):

Forward 5′-AATTACAACCAGAGCTTGGC-3′

Reverse 5′-TATCACTTTCCATAAAAGCAAG-3′.

The PCR reaction for each sample was done in a mix with a final volume of 50 µl containing: 1U of Taq Gold DNA polymerase (Life Technologies, Rockville, MD), 8.4 µl PCR buffer including dNTPs, 100ng genomic DNA and 10 pm for each primer based in our laboratory protocols.

PCR amplification program was selected from (Sviri *et al*., 1999) as follows: initial denaturation step 94 ˚C for 10 min followed by 35 cycles consisting of denaturation 94 ˚C for 1 min, annealing 60 ˚C for 1 min, extension at 72 ˚C for 1 min and final extension of 72˚C for 10 min. PCR Amplification was performed on the device Eppendorf Mastercycler ©

personal (eppendorf). Ten µl of the PCR mixture was then electrophoresed on 2% agarose gel and visualized under UV illumination. The 169 bp PCR fragment was expected.

RFLP analysis

For the identification of CYP2C19*2 allelic variant, the 169 bp fragment were digested with the SmaI restriction enzyme (New England Biolabs, Schwalbach, Germany), at 25˚C overnight. The restriction fragments were analysed on a 2% agarose gel electrophoresis stained with bromide ethidium. The CYP2C19*1 allele (wild type) is typically spliced in two fragments of 120 bp and 49 bp. The CYP2C19*2 allele as a result of G<A substitution at position 681 is not digested by SmaI restriction enzyme and is represented by a single fragment of 169 bp fragment in agarose gel. Individuals that are heterozygous for CYP2C9*1 and CYP2C9*2 alleles are identified by the presence of three fragments 169 bp, 120 bp, and 49 bp long in agarose gel as in Figure 1 depicted.

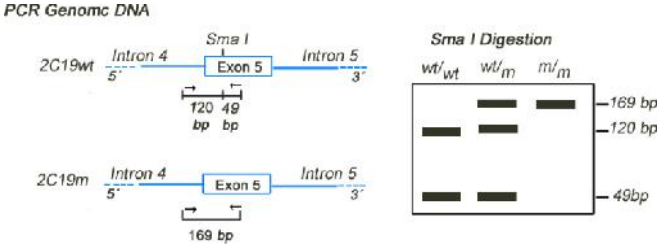

Fig. 1: Schematic presentation of genotyping by using the SmaI restriction enzyme.

2.4 Calculation of allelic frequencies

The frequencies of CYP2C9*1 and CYP2C9*2 alleles were calculated by using standard formulas of genetic population:

Frequency of allele CYP2C9*1 = 2 x n(AA) + 1 x n(Aa) / N total x 2

Frequency of allele CYP2C9*2 = 2 x n(aa) + 1 x n(Aa) / N total x 2

where: n(AA) – is the number of homozygous individuals for CYP2C9*1 allele; n(Aa) – is the number of heterozygous individuals for CYP2C9*1 and CYP2C9*2 allele; n(aa) – is the number of homozygous individuals for CYP2C9*2 allele. N total – the total number of individuals involved.

2.5 Statistical analysis

The Hardy-Weinberg equilibrium is calculated according to the chi-square test in accordance with the on-line software Online Encyclopaedia for Genetic Epidemiology studies (OEGE).

To determine the reliability of the allelic frequencies found, we calculate the standard deviation by the formula $\sigma = \sqrt{\frac{pxq}{2N}}$ where p- is the frequency of CYP2C19*1 allele, q- is the frequency of CYP2C19*2 allele and N- the total number of individuals involved. For each variant 95% CI confidence intervals were calculated.

To compare the CYP2C19*2 allele frequency found in our study with those of other populations was used the statistical test $\chi 2$ in SPSS statistical software, $p < 0.05$ values were considered insignificant.

3. RESULTS

All 69 DNA samples were successfully amplified based on the aforementioned protocol and produced a 169 bp PCR product. Figure 2 depicts the agarose gel electrophoresis showing the products amplified after PCR reaction.

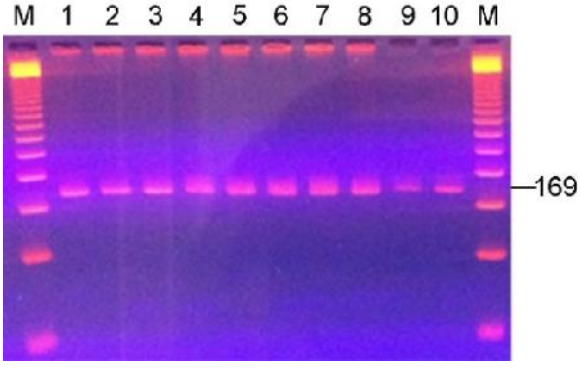

Fig. 2: The 169 bp fragments obtained by the PCR reaction analyzed in 2% agarose gel for 10 individuals. M- DNA marker, 50bp ladder.

The PCR products were digested by Sma I restriction enzyme for the determination of the appropriate genotypes for each subject. The digested fragments were analysed in gel electrophoresis as in Figure 3 depicted and were used for determination of CYP2C19 genotypes.

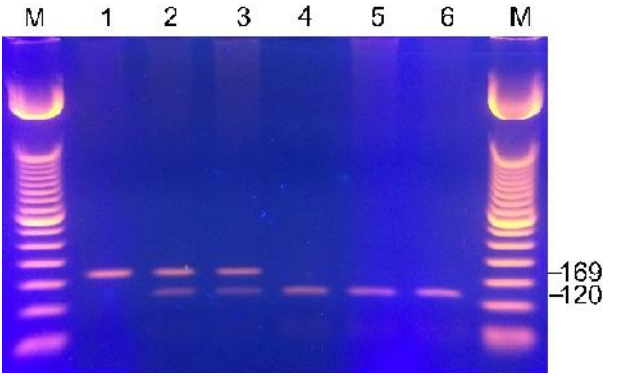

Fig. 3: Photo of gel electrophoresis in 2% agarose gel of PCR products digested by SmaI restriction enzyme. M-DNA marker, 50 bp ladder; number 1 undigested DNA fragment, number 2-6 DNA samples genotyped. The 49 bp fragment is invisible in this gel.

Individuals number 4 - 6 represented by one restriction fragment of 120 bp, has homozygous genotypes, CYP2C19*1/*1 while samples 2, 3 represented by two fragments of 169 bp, 120 bp are heterozygous for allele CYP2C19*1 and CYP2C19*2, (CYP2C19*1/*2).

The frequencies of CYP2C9*1/*1, CYP2C9*1/*2 and CYP2C9*2/*2 genotypes are respectively 57.4%, 41.2% and 1.47%. Based on known formulas of genetic population, we have calculated the frequencies of CYP2C19 alleles. The frequency of CYP2C19*1 allele was found to be 77.9% (76.54-79.26) while the frequency of CYP2C19*2 allele was found to be 22.1% (19.56-24.64). The frequencies of CYP2C19 genotype distribution and allele frequencies are in Table 1 reported.

Table1: CYP2C19 genotypes and allele frequencies in healthy Albanian population

Gene	Genotype	n	Frequency (%)	Allele	n	Frequency (%)	95%CI
CYP2C19	CYP2C19*1/*1	39	57.4	CYP2C19*1	106	77.9	76.54-79.26
	CYP2C19*1/*2	28	41.1	CYP2C19*2	30	22.1	19.56-24.64
	CYP2C19*2/*2	1	1.5				
	Total	68			136		

The frequencies of CYP2C19 genotypes and alleles in our sample was found not to deviate significantly from the Hardy-Weinberg equilibrium ($\chi 2=2.65$). There are no data available for Albanian population regarding

CYP2C19*2 allele frequency. The frequency of CYP2C9*2 allele found in our study is compared with frequencies found by other authors for different Balkan and European populations (Table 2).

Table 2: Distribution of CYP2C19*2 allele in different ethnic groups

Populations	Number of subjects analyzed	Frequency of CYP2C19*2 allele (%)	Reference
Albania	68	22.1	Our study
Kosovo	234	13.0 (p=0.009)	Krasniqi *et al*., 2017
Macedonia	198	18.6 (NS)	Nestorovska *et al*., 2010
Bosnia Herzegovina	77	17.0 (NS)	Semiz *et al*., 2010
Greece	283	13.1 (p=0.0006)	Arvanitidis *et al*., 2007
Italy	360	11.9 (p=0.0001)	Scordo *et al*., 2004
Turkey	404	12.0 (p=0.0012)	Aynacioglu *et al*.1999
Rumania	200	13.8 (p=0.022)	Buzoianu *et al*., 2010
Slovenia	129	15.9 (NS)	Herman *et al*., 2003
Bulgaria	96	13.5 (p=0.043)	Kovacheva *et al*., 2016
Croatia	200	15.0 (NS)	Božina *et al*., 2003
Hungary	535	12.5 (p=0.00224)	Nyírő *et al*., 2012
Slovakia	112	11.1 (p=0.005)	Krajcıova *et al*., 2014
Sweeden	162	15.0 (NS)	Chang *et al*.,1995
France	359	18.3 (NS)	Thiebault *et al*., 2008

**NS- Not significant*

The frequencies found in Greece (13.1%;283) (p=0.0006), Italy (11.9%;360) (p=0.0001), Rumania (13.8%;200) (p=0.022), Slovakia (11.1%;112) (p=0.005), Bulgaria (13.5%;96) (p=0.043), Hungary (12.5%;535) (p=0.00224), Turkey (12.0 %; 404) (p=0.0012), and Kosovo (13.0; 234) (p=0.009) differ significantly from the frequency of CYP2C19*2 allele found in our study while frequencies found in Macedonia (18.6%;198), Slovenia (15.9;129), Croatia (15.0%;200), France (18.3%;359), Sweden (15.0%; 162) and Bosnia Herzegovina (17.0%;77) has no statistically significant difference.

4. DISCUSSIONS

The analysis of genetic polymorphisms is a new field of research to better understand the linkage between genetic individuality and response to certain medical treatment. Today's pharmacogenetics aims to provide clinicians with a variety of new screening tests for different genetic polymorphisms. Genetic changes affecting the metabolism of drugs are reflected in changes in the

clearance, half-life or maximum concentration of a drug in plasma. These changes should be taken in consideration for adjusting the drug dosage depending on patient genotype (Gardiner *et al*., 2006).

Based on the result of our study, it would be expected that more than 4.9% of Albanians could be PMs for CYP2C19 drug substrates. The PCR-RFLP methodology used in our study is specific only for the identification of CYP2C9*2 allele. Within the group of subjects considered homozygous for normal allele (CYP2C9*1/*1) there may be individuals carriers of other variants of the CYP2C9 gene that are not identified with the protocol applied in these studies. CYP2C19 defective alleles, such as CYP2C19*3, *4, *5, *6, *7, *8, have been reported to contribute to the PM phenotype in Caucasian populations. *CYP2C19*17* is a novel variant allele which increases gene transcription and therefore results in ultra-rapid metabolizer phenotype, it has a high frequency among Caucasians, around 21% (Sim *et al*., 2006). Taken in consideration that these variants haven't been studied in our population yet, their presence can lower the frequency of CYP2C9*1 allele.

CYP2C19 genetic variation represents an important factor in the effectiveness of some medically prescribed drugs. Clopidogrel is widely used for the prevention of cerebrovascular and cardiovascular disorders (Chen *et al*., 2005). According to data provided by University Hospital "Nënë Tereza" there are about 3.000 individuals that are hospitalized each year with acute myocardial infraction in Albania which are treated with clopidogrel (marketed as Plavix). According to data obtained by our study 146 individuals from these categories may result PMs. Bioactivation of clopidogrel does not take place due to the presence of CYP2C19*2 allelic variant, increasing the risk for myocardial infraction (Geisler *et al*., 2006). Alternative antiplatelet therapy recommended if no contraindication, e.g., prasugrel or ticagrelor. The Food and Drug Administration (FDA) made it mandatory in the USA to indicate CYP2C19*2 allele frequencies for different populations in Medication Guides highlighting the fact that effectiveness of the drug varies among patients according to their genotypic profile.

According to the results of multiple proton pump inhibitors (PPI), CYP2C19 genetic variation represents an important factor affecting the pharmacokinetics of most of the PPIs (Schwab *et al*., 2004). Several trials have demonstrated that cure rates of *Helicobacter pylori* infection were significantly lower in EM compared to IM or PM. On an average, the latter two phenotypes had about 15 to 20% higher *H. pylori* eradication rates than EM (Klotz *et al*., (2004).

CYP2C19 has also a role in the biotransformation of the antiepileptic drug phenytoin, antidepressant drug amitriptyline, imipramine Clomipramine and citalopram. CYP2C19 metabolizes some benzodiazepines as well including diazepam, quazepam, clobazam, flunitrazepam. Diazepam is the most studied

drug in relation with CYP2C19 genetic variation. The overall defect in PMs is an increased exposure to diazepam and thus a prolonged effect (Qin *et al*., 1999; Dean 2016) which could lead to excessive central nervous system depression.

All the aforementioned drugs are currently the most frequently used in practice genotyping prior starting the therapy could be a reasonable approach with respect to the optimal dosage adjustments and treatment cost-effectiveness. For the first time we have data about polymorphism of CYP2C19 gene in Albanian healthy population.

Evaluation of genetic variants of CYP2C19 gene is part of pharmacogenetic tests. The application of this test is of great clinical importance for the determination of drug doses in contemporary medical treatments. Through this pharmacogenetic test it becomes easier for clinicians to determine the dosage and the type of medication for the patient based on their respective CYP2C19 genotype to benefit from the medical therapy treatment.

5. CONCLUSIONS

The frequencies of CYP2C9*1/*1, CYP2C9*1/*2, CYP2C9*2/*2 genotypes in 68 subjects of healthy Albanian individuals were 57.4%, 41.2%, and 1.47% respectively. Genotype distribution were in accordance with Hardy-Weinberg equilibrium.

The frequencies of CYP2C19*1 and CYP2C19*2 alleles were respectively 77.9% (84.53 - 87.47) and 22.1% (19.56-24.64).

This is the first report of Albanian population regarding the two alleles of the CYP2C19 gene CYP2C19*1 and CYP2C19*2.

The frequency of CYP2C19 *2 allele (22.1%) found in Albanian population is the highest found in Europe.

As the IM and PM represent 1/3 of Albanian population, high risk of adverse drug reaction may be expected from this group. It is of potential clinical importance the identification of individuals who have decreased metabolism for CYP2C19 substrates.

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RESISTANCE OF ESCHERICHIA COLI TO QUINOLONES IN ALBANIA

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ABSTRACT

Escherichia coli (*E. coli*) is a common resident of humans and animals, but it can be a real risk to them, causing serious diseases. Quinolones are synthetic compounds, with a broad action spectrum, and of particular importance due to their oral use in the treatment of infections. Resistance to them may be due to mutations of the target site and the transmission of plasmid resistance genes. The purpose of this study is to highlight the phenotypic resistance of *E. coli* isolates and compare the results with international data. Isolates were obtained from inpatients and outpatients at the University Hospital Center "Mother Theresa". A prospective study was conducted for 207 isolates of *E. coli* during the from 2015 to 2017. The level of resistance of *E. coli* to quinolones was 34.7%.
***Keywords*:** isolates, genes, phenotypic, level

1. INTRODUCTION

E. coli is part of the normal flora of humans and animals. Nevertheless, it is: i) the most common cause of urinary tract infections acquired in the community and in hospital environments, ii) one of the most common causes of blood infections, at all ages, iii) the associate of intra-abdominal infections such as peritonitis, as well as skin and soft tissue infections, iv) one of the

most common causes of meningitis in neonates and, v) one of the major causes of food-related infections worldwide (WHO, 2014).

E. coli infections can be endogenous or auto-infectious, while special resistance strains can be transmitted exogenously from animals, either through the food chain or between individuals (WHO, 2014).

Quinolones are among the most commonly used antibiotics for oral treatment of community infections. Probably they are the most common antibacterial agents for the treatment of urinary infections where *E. coli* is the most common cause (WHO, 2014).

Quinolones are synthetic antibacterial compounds whose precursor is nalidixic acid. It was described for the first time in (Lesher *et al*., 1962; Couvarlin and Reclercq, 2012) and created as a byproduct of chloroquine synthesis and introduced into use for the treatment of urinary infections (Hooper, 2005).

All molecules have a pyridine cycle. Fluoroquinolones are characterized by the presence of a fluorine atom at position 6 and a piperazine cycle at position 7.

The systematic observation of *E coli* resistance to antibiotics is important for the impact of this resistance to health and treatment costs

Albania does not have official data on the resistance of *E. coli* to quinolones (WHO, 2014). In several studies by Albanian authors, the resistance of *E. coli* isolates from nosocomial urinary tract infections to ciprofloxacin is 50%, while for outpatients it is 41% (Kasmi, 2010). For intestinal carriers of resistant isolates of Enterobacteriacae and non-fermenters, resistance to ciprofloxacin is 30% (Tafaj *et al*, 2017) and, for non - ESBL *E. coli* and Klebsiella sp isolated in urine, the resistance to ciprofloxacin is 39.7% (Mano, 2016).

Since the "Mother Theresa" University Hospital Center is the largest tertiary care center in Albania for inpatients and outpatients, an assessment in this center would give an idea of the level of *E. coli* resistance to quinolones in the country.

OBJECTIVES

The present study aims to assess the resistance level of *E. coli* isolates to quinolones and compare the assessment data with international ones.

1. MATERIALS AND METHODS

This is a prospective study. All *E. coli* isolates, for which an antibiotic susceptibility test report exists, have been studied. A total of 207 *E. coli* isolates, secured from the total isolates obtained from various clinical

inpatient and ambulatory material for the period 2015-2017, in the University Hospital Center "Mother Theresa", were studied.

Sensitivity detection and determination of these *E. coli* isolates to antibiotics was carried out using the automated system, Vitek 2 (BioMérieux). The bacterial susceptibility to quinolones was determined based on MIC to Ciprofloxacin in accordance with the European Committee on Antimicrobial Susceptibility Testing (EUCAST) standards where isolates are considered susceptible when MIC < 0.25μg / ml, and resistant when MIC > 4μg /ml. Data entry and processing was done using the Microsoft Office Excel 10 program and IBM SPSS Statistics version 20. For the comparison of percentages, the Chi-Square goodness-of-fit test was used.

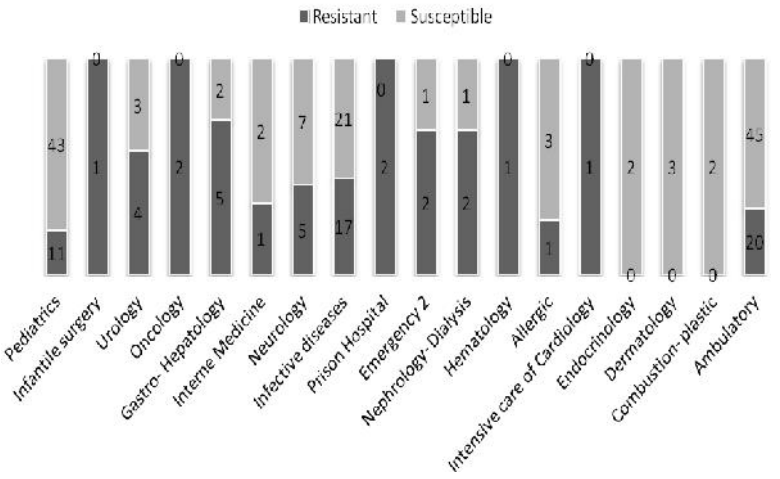
2.RESULTS

Table 1 reports that 72 out of 207 isolates resulted resistant to quinolones. In total, the resistance level is 34.8%.

Table 1: Distribution of *E. coli* isolates and susceptibility to quinolones

Clinical sample	**Susceptible N (%)**	**Resistant N (%)**	**Total N (%)**
Blood cultures (invasive isolates)	3 (1.5)	2 (1.0)	5 (2.5)
Vaginal/urethral swabs	5 (2.4)	1(0.5)	6 (2.9)
Sputum	1(0.5)	1(0.5)	2 (1.0)
Fecal	50 (24.1)	13(6.2)	63 (30.4)
Urine	72 (34.8)	53 (25.6)	125 (60.3)
Pus	4 (1.9)	2(1.0)	6 (2.9)
Total	**135 (65.2%)**	**72 (34.8%)**	**207 (100)**

Chart 1: Distribution of E. coli isolates by wards



Referring to related world-wide data, WHO Report informs the following rate ranges: European region 8-48%, Eastern Mediterranean region 21-62%, South East Asia region 32-64%, Western Pacific region 3-96%, The African region results 14-71%, the American region 8-58% (WHO, 2014).

Referring to related regional data, the evidences show the following rates: Serbia = 16%, Croatia = 14%, Greece = 26.6%, Italy = 40.5% (WHO, 2014).

3. DISCUSSION

In the 1980s, fluoroquinolones increased the power, in the first meaning of the word, among which specific urinary products such as enoxacin, lomefloxacin and norfloxacin, as well as systemic products of ciprofloxacin, ofloxacin and pefloxacin that showed a superior intrinsic activity over enterobacteria and against staphylococci and to some extent even against pseudomonas (Couvarlin and Reclercq, 2012).

The introduction of new molecules (levofloxacin, moxifloxacin, gatifloxacin) has allowed a new expansion of fluoroquinolone indications, especially in respiratory infections due to prominent pneumococcal activity, but without improvement of performance against enterobacteria and other Gram-negative bacteria (Couvarlin and Reclercq, 2012).

In Albania, quinolones are the fourth most common antibiotic group used after penicillins, tetracyclines and macrolides. Their use recognizes an upward trend, more specifically from 1.72 to 2.51 DID (daily dose per 1000 inhabitants) for the years 2011-2012. (Hoxha et al, 2015).

The quinolones exert a selective inhibitory effect on bacterial DNA synthesis by acting on two enzymes that participate in this synthesis: DNA topoisomerase II, otherwise called DNA gyrase, and DNA topoisomerase IV (Couvarlin and Reclercq, 2012).Although the main target of quinolones in Gram negative bacteria is the DNA gyrase (Drlica *et al*., 2008), after 1990 another quinolone intra-cellular target has been identified and this is the DNA topoisomerase IV. This enzyme was detected in E. coli and later found in other bacterial species as well (Couvarlin and Reclercq, 2012). The basis of interaction of quinolones with the Topoisomerase IV is the formation of a water-metal ion bridge between the oxygen molecules in the amino group of the drug and the hydroxyl residues in conserved serine or acidic residues in the enzyme mediated by a Mg2 + ion (Aldred, *et al*,. 2013; Sissi, *et al*., 2013)

Resistance to quinolones, in some circumstances, is the indicator of resistance to the only possible oral treatment.

E. coli resistance to fluoroquinolones develops mainly because of mutations belonging to the target site and/or permeability of the membranes. Target mutations are gene mutations that code DNA gyrase and topoisomerase IV the target site where quinolones act, (Redgrave *et al*. 2014).

Resistance obtained from fluoroquinolones in Gram negative bacilli has been considered to be exclusively caused by chromosomal mutations until the 1998 description of plasmid resistance (Soussy, 2012).

Various genes encoding different resistance mechanisms on mobile genetic elements can decrease susceptibility to quinolone or fluoroquinolone antibiotics; these are often encoded on plasmids and known as plasmid-mediated quinolone resistance (PMQR) genes. The archetypal gene, transmitted with this mechanism is *qnr* gene (Redgrave *et al*. 2014). The protein it encodes is characterised by a pentapeptide-repeat motif and has similarities to immunity proteins such as McbG (Tran and Jacoby, 2002). Data from a recent structural analysis of a Qnr protein suggest that resistance to fluoroquinolones is achieved by the binding of the Qnr protein to the topoisomerase, which physically prevents the intercalation of the antibiotic with the target enzyme (Xiong *et al*., 2011).

Our data in terms of antibiotic resistance in general and resistance to quinolones in particular are fragmentary. This is related not only to the lack of a system of antibiotic stewardship but also to the lack of materials such as kits and reagents necessary to determine the sensitivity of antibiotics, or sequencers for the determination of resistance genes.

4. CONCLUSIONS

E. coli resistance to quinolones is 34.8%. Albania's rate is within both global and European rate ranges reported by WHO.

Collection, analysis and reporting of *E. coli* resistance to quinolones is of great importance to the treatment of serious infections and for seeking alternative oral treatments for both community and hospital infections. The surveillance of the resistance to quinolones should be steadily and continuously evidenced along with the resistance to other alternative oral treatments of the most common infections caused by *E. coli* (although the latter is not the subject of the present study), because in the absence of alternative oral medications, injectable medicines are to be used, entailing increased treatment costs for the patient and the health care system.

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DATA ENCRYPTION, PARTITION AND DISTRIBUTION STRATEGIES FOR USER-CONTROLLED SECURITY IN THE CLOUD

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ABSTRACT

Cloud storage services have considerably increased. However, security and privacy issues still pose significant challenges. Here, encryption of data at rest would be useful. Data encryption at rest require efficient key management, access permissions. In this paper, we propose a new approach to security controlled by the IT security specialist (ITSS) of the company i.e., the file owner based on multiple strategies of file encryption, partitioning, and distribution among multiple storage providers, resulting in increased confidentiality since a supposed attacker needs to first obtain parts of a file from different storage providers, know how to combine them, before any decryption attempt. In addition, the proposed approach compares to different enterprise-wide encryption strategies. All details of the strategy used for a particular file are stored on a separate file, which might be considered as a master key for the file contents. In the end, the results and comments related to the realized measurements are reported.
***Keywords*:** cloud security, ITSS - IT security specialist, encryption, decryption, partitioning, confidentiality, cloud service provider, cloud service client

1. INTRODUCTION

The cloud computing is the technology deriving from a cluster grid computing, component-based composition, and lately, service-oriented architecture and web services, all described by the cloud computing. In the traditional technology, the software and the hardware are two separate components. In the cloud computing the hardware, software, CPU power,

storage, platform, application software etc. are offered as a service. Consequently, cloud computing has become preferable.

Cloud computing is advantageous due to its flexibility in managing the space, automatic software update, accessible, pay based on services, etc.

Yet, there is a complex problem regarding the data security in the cloud, which makes it more critical when the data in question is highly sensitive, or the enterprises do not trust to the cloud provider. The encryption of data at rest is one of the main issues related to security in the cloud computing and especially cloud storage (Chauhan *et al*., 2013; Puzio *et al*., 2013).

To control security from the ITTS of the company/organization, we have proposed a model as an adequate system solution in the cloud computing, (Hyseni *et al*., 2015). In our model, the main actor that manages the security of the data storage in the cloud is the ITSS of the company itself. The ITSS selects different security parameters, such as encryption algorithms and keys, as well as partitioning strategies to distribute files in the cloud. However, all files transferred to the cloud should follow these organization-wide rules in the future, based on the security, latency and cost.

The later part of the paper is organized as follows: motivation, state-of-the-art and results of other researches, the fourth section contains analysis of the model proposed for security in the cloud, the fifth section contains implementation of model proposed for security in the cloud, the six section presents the way of partitioning, encryption and distribution strategies used for proposed model, the seventh section introduced the results of the measurements for the proposed strategies, and the final section outlines the field of the future work.

2. Motivation

The Ponemon Institute carried out in 2017 a study on the global encryption trends financially supported by the Thales e-Security and the data obtained were a means to address the present investigation which is based on: i) data storage in the cloud and, ii) the model of a secure and model of storing data in the cloud.

Here, cryptography is of irreplaceable importance as it concerns itself with confidentiality, integrity and non-repudiation.

However, there is still a gap in organizations because they require a maximum protection of sensitive data from inside and outside the attacks. Very noted companies were involved in the study committed to improving encryption and security (Memti *et al*., 2015). The first steps in the creation encryption strategies in the cloud computing were studied in the USA in 2005, and then this field started to develop all over the world. Different data have been collected by the end of each year, and research was based on security factors.

We have closely analyzed some very important elements of the proposed model for the security in the cloud, the Thales e-Security (2017), the way of storing data by the organizations once sent to the cloud.

In the study, 46% of the respondents answered that encryption is carried out on premise prior to sending data to the cloud with keys they generate/manage. In addition, 21% of them said that they allow encryption in the cloud but with keys that are generated and managed on premise and 37% of them relayed completely to the provider offering space in the cloud such as key generation and its management.

The industries that were interested in improving the encryption strategies for financial services, transportation, technology and software, health and pharmacy, hospitality, consumer products, public sector and its growth over the years were also involved.

54 percent of the responders said that the main threats that might result in the exposure of sensitive or confidential data are due to the employees' mistakes.

Information related to the management of encrypting keys— starting from the encrypting keys to host services up to the keys for archiving and backup data—is difficult to manage during the encryption process.

About the way of organizing the data to be stored on the cloud, 46 percent of the responders said that the encryption is performed on-premise prior to sending data to the cloud using keys their organization generates and manages. 37 percent of respondents perform encryption in the cloud, with cloud provider generated/managed keys. 21 percent of the respondents allow encryption in the cloud but with keys that are generated and managed on premise.

3. State of the art

Based on the literature review, the forthcoming paragraph provides solution to security in the cloud computing. The proposed model from (Khan *et al*., 2009), consists of three different security scanners with different choices depending on their requests from interested parties for use in the cloud computing (Fig.1).

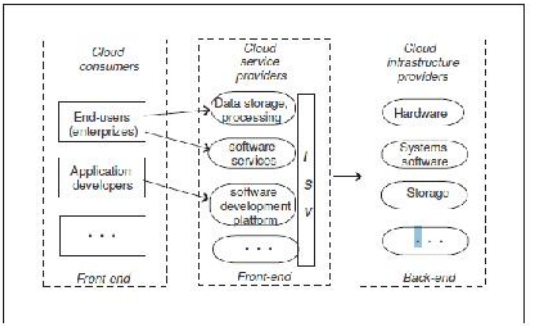

Fig.1. Levels of Abstractions of Cloud Computing.

The researchers began to carry out a common analysis of security in the cloud computing modules. Subsequently, they were focused on the elementary requirements to secure a system's cloud protection. Their work orientation is geared towards the Advanced Cloud Protection System (ACPS), which is the result of security for the Linux Kernel Virtual Machine. In this scientific work through the ACPS, it is possible to protect the integrity of virtual machines (VM) and distributed computing middleware, which appear as supporting elements in the cloud environments. Different monitoring offered by the VMs in cooperation with the components of the infrastructure is proposed against the various attacks (Ouedraogo *et al*., 2015).

Rodero-Merino *et al.*, (2012) made a survey about the security offered on the multi-tenant software platform, as part of the PaaS Model. In the PaaS Model, they discovered the technical weaknesses of the multi-tenancy support platforms, similar to the Net or Java. In this paper, the authors suggested that the code is to be isolated inside the PaaS by the CSC and the probability of possible errors in the other applications be reduced. Based on the two weaknesses such as during the application development, all the rules to ensure this code is developed in the PaaS it will be beneficial the hackers. As a conclusion, the CSP for the PaaS Model should use all the possible mechanisms provided by the security environment, to minimize the potential risks that come to this model. Encryption is seen as a choice of the data security. During processing and rest of the database and the data has not been tampered with or seen by the other parties in the cloud environments. Although it has been proposed to encrypt the data for the above-mentioned problems, it is not safely to those problems. In the cloud environments, exploited patterns (for management, data processing and storage), security and privacy processes cannot be used with the same encryption techniques as traditional the ones (Ouedraogo *et al*., 2015).

The primary challenge in terms of using the data encryption in the cloud environments is the cryptic management. The first and very important element is the security of the encrypted cells, to avoid problems rising after detection of the cells. By providing these cages, we mean, the way and the place where they were stored. Access to these keys must be done by the authorized persons only, but by other cloud computing parties. Another important element is to ensure the regeneration of these cells, in case they are lost or damaged by the members of the cloud (Kerschbaum 2013).

Researches about cloud data integrity techniques have been made. Zhu *et al*., (2012) proposed security for integrity and privacy of the data based on the efficient audit at low cost. It was also proposed the audit to be carried out by a third-party auditor (TPA), which audits the data from time to time and the same data become available to the client by passing the load and the cost for validation and downloading data at the local level. Practically, this is presented in this way; the data owner has assigned a secret cell used to process the file, which is divided into several blocks. Before sending the file and the verification parts to the CSP, one part of the public verification information is already generated and stored in the TPA. Based on the requirements of the data owner, the TPA uses the data retrieval protocol and then enables auditing or controlling data integrity by using public verification information. The perception of this architecture is that it can be implemented in the TPA without including the data owner. Wang *et al*., (2010) suggested the third-party privacy and auditing problems and the data integrity to be resolved via TPA. In the present paper, the integrity audit is supported by using the homomorphic encryption. Solutions for a higher efficiency of the TPA, which tries to offer both data collection techniques, integrity and the data privacy have been proposed.

4. Model proposed for security in cloud

Figure 2 depicts the security model in the cloud computing proposed in (Dhurata *et al*., 2015). In this model the security control depends on the ITSS of a certain organization, the security options are selected based on security algorithms.

The proposed model increases security in the cloud, offering the following scenarios based on the data sensitivity:

Scenario I: Security is based on the choice of the ITTS organization, depending on the information proposed by the model offers.

Scenario II: Based on the features of the file, algorithms which are proposed and the ITSS make a choice.

Scenario III: Security, based on the file encryption and partition by the ITSS of organization with two possibilities:

A: The file is partitioned and then encrypted in particular parts (P1, P2,…, Pn) and

B: The file is encrypted and then partitioned in particular parts (P1, P2,…, Pn)

Each part can be stored in different clouds. A new file P0, contains selected algorithms, index and position of the file. File P0 is significantly smaller, encrypted by a more powerful algorithm and can be stored anywhere in the cloud or in the local machine.

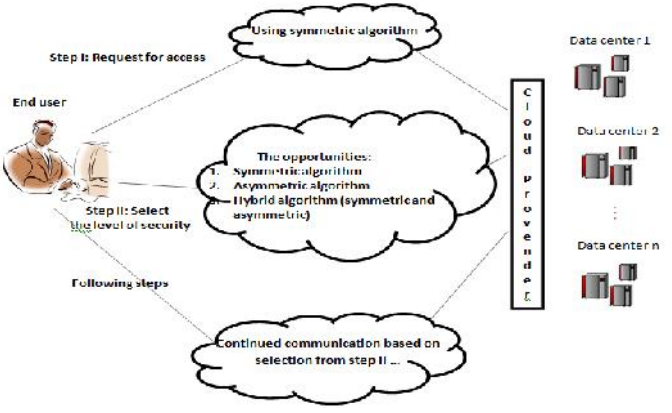

Fig. 2. Security model in the cloud computing controlled by the ITS specialist (Hyseni *et al*., 2015; Hyseni *et al*., 2016).

5. Implementation of the proposed model

The proposed model is implemented on the NET Framework, which is developed by Microsoft that runs primarily on the Microsoft Windows. The GUI was developed using Framework 4.5, in the programming language c#. The proposed cloud security model (named "eSiguria") consists of three main modules as depicted in the Figure3:

Configuration (Konfigurim),
Document (Dokument) and
Administration (Administrim)

Depending on the user's role in the organizations, they are going to be active in these modules.

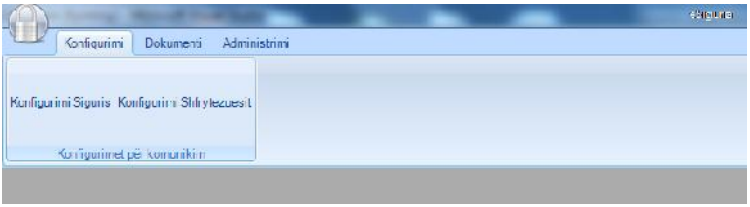

Fig.3. Modules in "eSiguria".

Regarding the configuration module, only the ITSS has the access in the organization. Knowledge about the mode of communication and the opportunities offered by the application is available to this actor to continue with security configurations.

The parts of the configuration module are:

Security Configuration creating populates with data and details about security configurations. This can be called differently and the communication rule, which is created once and then exploited by the users. First, there are different rules of communication within an institution, and depending on the sensitivity of the data work that the users realize in the institution (Figure 4).

User Configuration - User Configuration Forms make the connection to the security configuration form to the previously registered user. Part of this form is: No. Configuration to be selected as well as the organization users.

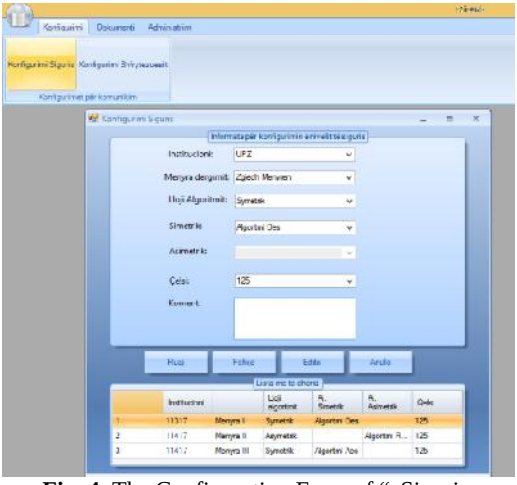

Fig. 4. The Configuration Form of "eSiguria

The other module is the Document, part of this module is the Send Document (the way how to send the cloud file, the file location and the sharing method). This module is active for any user who has an account in the institution/organization.

Part of the “eSiguria” application is also the administration module, which consists of standard forms for administering an application, and has access to all users in this application. Based on the Fig.5, it is obvious that the entire workflow depends on this model which is based on the ITSS. Configuration of this communication rule is accomplished by the ITSS of an organization, then all the communication used for other members is based on this rule.

For the database management of the “eSiguria” application, we use the SQL Server. The Figure 6 shows that the No Configuration field is also recorded with its details in the Configuration table. Once recorded, the rules placed are transferred to the Spreadsheet and tblFile tabs.

tblConfiguration which determines rules of configuration by the ITSS except him no other person has any right to insert data from in this table)

tblUser (general data for the user and as additional field is the number of configuration that comes from Fig. 6, depending on which type of configuration should be chosen for the respective user)

tblFileDetails (general information for managing files and its partitions)

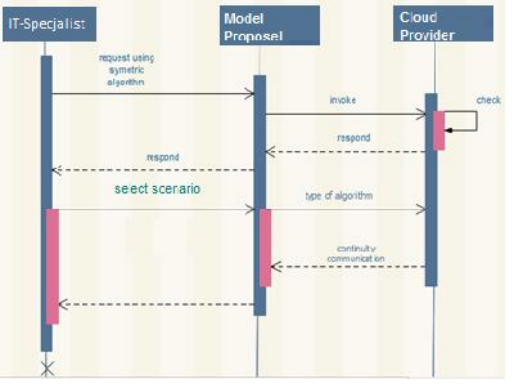

Fig.5. Workflow for the proposed cloud security model.

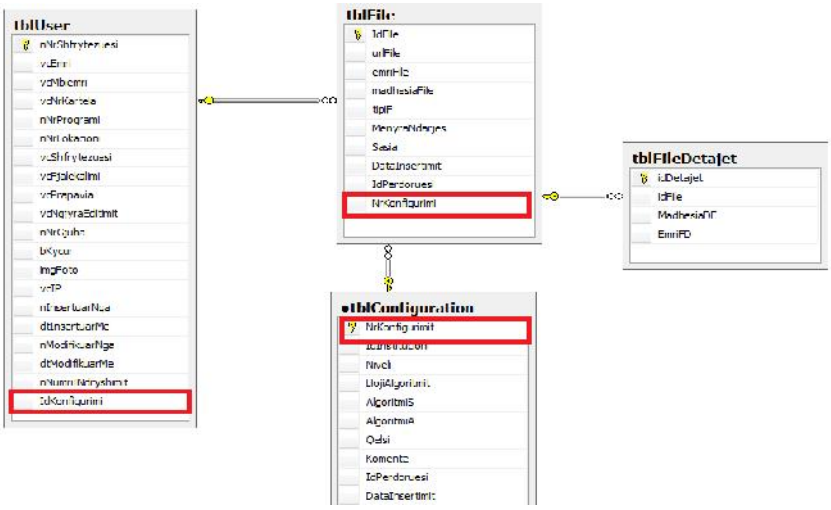

Fig. 6. Configuration of the level of security for users.

The security rules determiner is the ITSS (Fig. 5). Staff members within the organization should not be aware of the data security. It is sufficient to have access by the ITSS. As the mistakes of the employees are reduced, the access possibilities are minimized.

6. The strategy of data encryption, partition and distribution for proposed model

To provide secure communication in the communication channels we are going to use the encryption of the data, based on the technology improvement (Arora and Parashar 2013).

Considering the data encryption, we can use two different kinds of techniques of cryptography: i) symmetric algorithm, when same key is used for encryption and decryption and, ii) asymmetric algorithm, different keys are used for encryption and decryption.

Our proposed model not only uses these two techniques, but it also uses the combination of both symmetric and asymmetric algorithms, known as hybrid algorithms (Qingyong Li *et al.*, 2011).

The steps flowing for our proposed model to increase security in the cloud and steps that we need to follow in our proposed model:

Step I: Access to program using password and user name.

Step II: Selection scenario of security based on the sensitivity data (Scenario I, Scenario II or Scenario III).

Step III: Selection of algorithms of data encryption.

Step IV: Selection of uploading/downloading files to the cloud.

Abbreviation used	Content
p	Part of the file ready for processing.
P1, P2...Pn	Partitions of the file.
P1E, P2E...PnE	Encrypted respectively parts of the file.
CP1, CP2....CPn	CP that supports our proposed model.

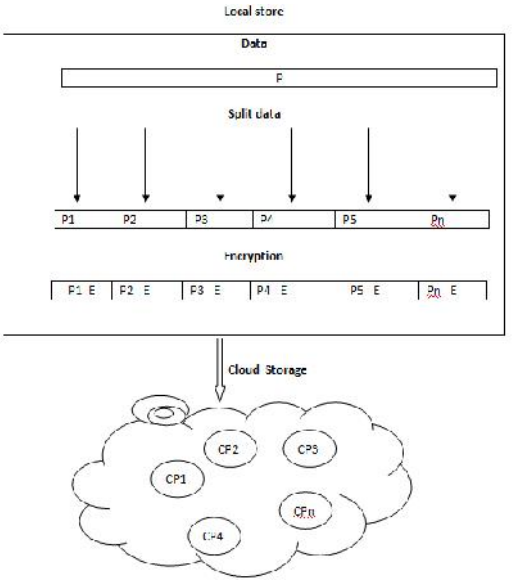

Fig. 7. Partitioned and then encrypted respectively parts of the file.

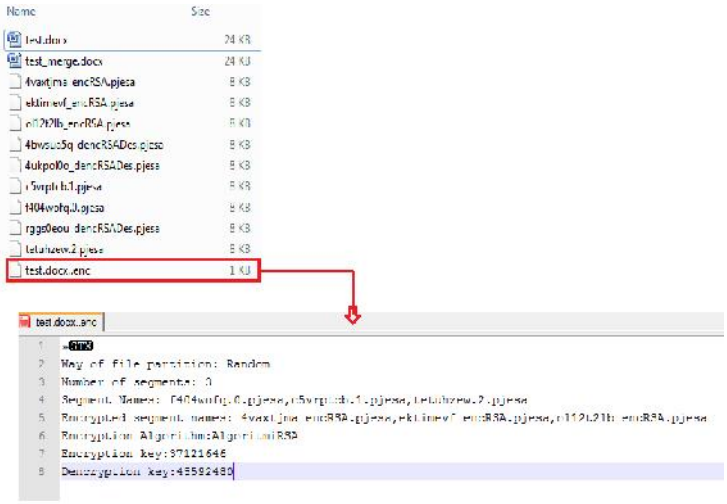

Fig. 8. Content of the file ..enc for first case

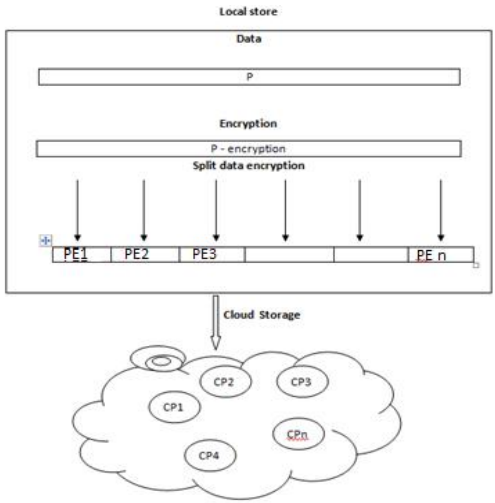

Fig. 9. Encrypted then partitioned file.

First scenario. Figure 7 shows a case where a test.docx file is used for testing. As a first scenario we selected the RSA Algorithm. Figure 8 shows a randomly done partitioning (Shamir, 1979) with a subsequent encryption of partitions and the information from this case test_merge.docx, which takes us to the first step.

In second proposed model we encrypt the file then we split it in partitions based on the scenario and algorithm selected. This scenario offers higher

security of the data, because we must have all parts of the file to be able to read them.

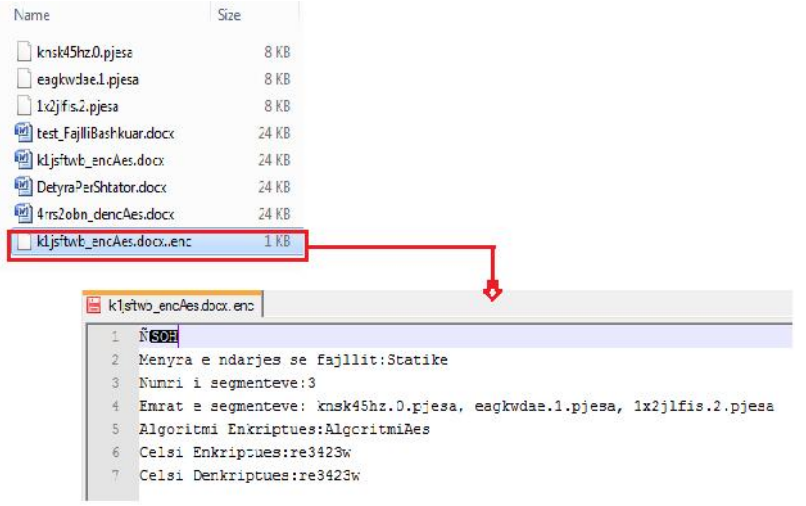

Fig. 10. Content of the file ..enc for second case.

The ***second scenario*** involved the model of figure 9. The "DetyraPerShtator.docx" is the texting file. We used AES, the symmetric algorithm as the configuration and then partitioning file in three parts. File with suffix *.enc* is created as with the random name *k1jsftwb_encAes.docx..enc*. This file is populated with the rule of safety configuration and the keys used for encryption and decryption.

Step V: Distribution of files to the cloud (Figure 7 and 9) shows the scheme of partitioning of files into smaller parts and storing them to the cloud.

Two ways of splitting the files in partitions are used: i) Random: is not dependent upon the size of the file and the number of Cloud providers, but even if we have used the function Random to determine the partitioning, within this function as parameters we have set minimum and maximum, for example Random (2,30) and, ii)Static: periodic partitioning randomized parts of the file to be placed in particular segments and then these parts to be distributed to the cloud providers, depending on the segments that are available.

7. Test and measurements for the application "e-Siguria"

Considering all measurements, we have the following working conditions: Processor: Initial (R) Celeron (R) CPU 1005 M 1.90 GHz, and network details, Ping: 55ms, Download: 15.46 Mbps, Upload: 2.22 Mbps.

For all measurements we have used the measuring unit of time execution in milliseconds (that must be considered for all vertical axes graphs). For every case of measurements, there have been two ways of measurements for Upload and Download.

Also, for measurements we have used the measuring unit of time execution in milliseconds (that must be considered for all vertical axes graphs). For every case of measurements, there have been two ways of measurements for Upload and Download.

Measurements are divided in the following main groups:

Group 1-Large size files, differ on the following characteristics: type of file: .doc, size of file: 2969KB, and the way of file partition: static way (three parts) and Uploading/Downloading them to three different providers. These were taken into consideration for two types of scenarios, Fig. 7- Case I and Fig. 9- Case II.

Table 1. *Time measurements for group 1*

No.	Process	Case	Algorithm	Key - bits	Execution time (ms)
1	Upload	I	RSA	1024	38009
1	Download	I	RSA	1024	33502
2	Upload	I	AES	128	24896
2	Download	I	AES	128	16644
3	Upload	I	Des	64	28434
3	Download	I	Des	64	21365
4	Upload	I	TripleDES	128	29234
4	Download	I	TripleDES	128	24689
1	Upload	II	RSA	1024	33607
1	Download	II	RSA	1024	30652
2	Upload	II	AES	128	28329
2	Download	II	AES	128	25100
3	Upload	II	Des	64	29452
3	Download	II	Des	64	27573
4	Upload	II	TripleDES	128	32039
4	Download	II	TripleDES	128	30683

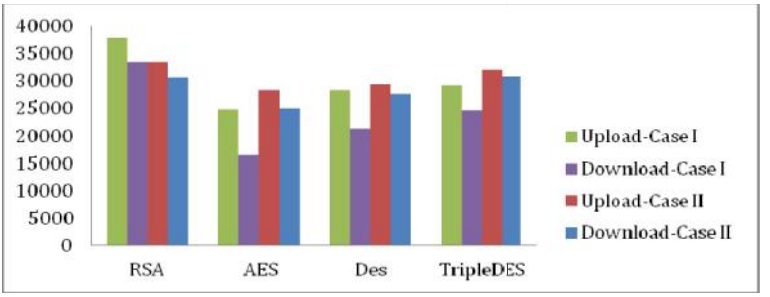

Fig. 11. Graph of the group 1.

Group 2: Different types of files: .pdf, .doc, .png with same size 606KB, using static way of partitioning (three parts) and Uploading/Downloading them to the cloud in three different providers. As in the above table these characteristics taken into consideration for two types of measurements, Fig. 7- Case I and Fig. 9- Case II.

2.1 The following table shows measurements for the .doc file.

Table 2. Time measurements for group 2.1

No.	Process	File type	Case	Algorithm	Key - bits	Execution time (ms)
1	Upload	.doc	I	RSA	1024	12432
1	Download	.doc	I	RSA	1024	11652
2	Upload	.doc	I	AES	128	10985
2	Download	.doc	I	AES	128	9638
3	Upload	.doc	I	Des	64	10972
3	Download	.doc	I	Des	64	10205
4	Upload	.doc	I	TripleDES	128	11721
4	Download	.doc	I	TripleDES	128	10080
1	Upload	.doc	II	RSA	1024	14438
1	Download	.doc	II	RSA	1024	11568
2	Upload	.doc	II	AES	128	11938
2	Download	.doc	II	AES	128	8269
3	Upload	.doc	II	Des	64	13726
3	Download	.doc	II	Des	64	9119
4	Upload	.doc	II	TripleDES	128	13865
4	Download	.doc	II	TripleDES	128	8584

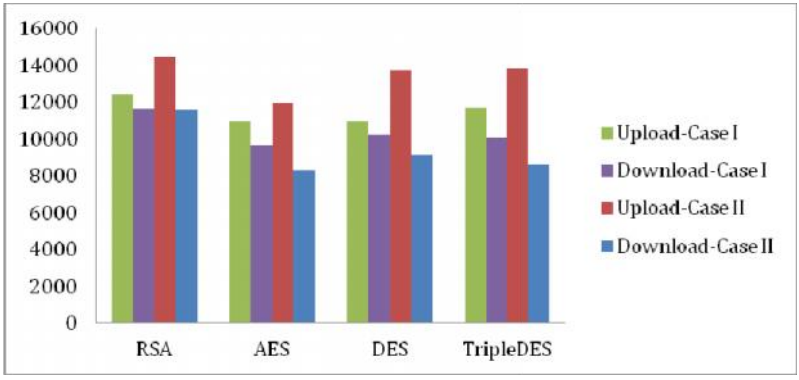

Fig. 12. Graph of the group 2.1.

2.2 The following table shows obtained measurements for .pdf file.

Table 3. *Time measurements for group 2.2*

No.	Process	File type	Case	Algorithm	Key - bits	Execution time (ms)
1	Upload	.pdf	I	RSA	1024	17108
1	Download	.pdf	I	RSA	1024	15986
2	Upload	.pdf	I	AES	128	10855
2	Download	.pdf	I	AES	128	9678
3	Upload	.pdf	I	Des	64	10181
3	Download	.pdf	I	Des	64	8734
4	Upload	.pdf	I	TripleDES	128	12431
4	Download	.pdf	I	TripleDES	128	9837
1	Upload	.pdf	II	RSA	1024	20724
1	Download	.pdf	II	RSA	1024	18503
2	Upload	.pdf	II	AES	128	13155
2	Download	.pdf	II	AES	128	11074
3	Upload	.pdf	II	Des	64	9010
3	Download	.pdf	II	Des	64	8583
4	Upload	.pdf	II	TripleDES	128	13431
4	Download	.pdf	II	TripleDES	128	9330

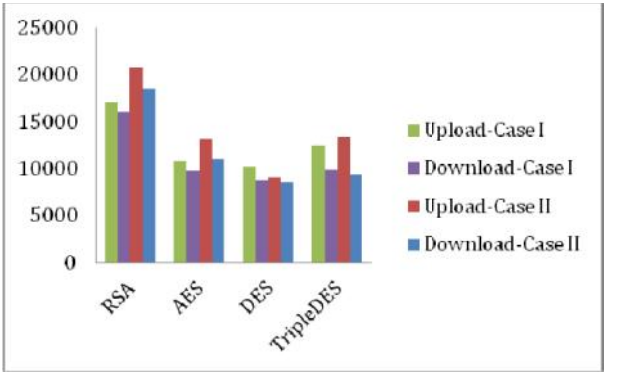

Fig. 13. Graph of the group 2.2.

2.3 The table 4 shows obtained measurements for the .png file.

Table 4. Time measurements for group 2.3.

No.	Process	File type	Case	Algorithm	Key - bits	Execution time (ms)
1	Upload	.png	I	RSA	1024	17187
1	Download	.png	I	RSA	1024	15300
2	Upload	.png	I	AES	128	10551
2	Download	.png	I	AES	128	9147
3	Upload	.png	I	Des	64	9732
3	Download	.png	I	Des	64	8446
4	Upload	.png	I	TripleDES	128	11389
4	Download	.png	I	TripleDES	128	10321
1	Upload	.png	II	RSA	1024	14979
1	Download	.png	II	RSA	1024	12620
2	Upload	.png	II	AES	128	10802
2	Download	.png	II	AES	128	9602
3	Upload	.png	II	Des	64	9796
3	Download	.png	II	Des	64	8217
4	Upload	.png	II	TripleDES	128	12093
4	Download	.png	II	TripleDES	128	8728

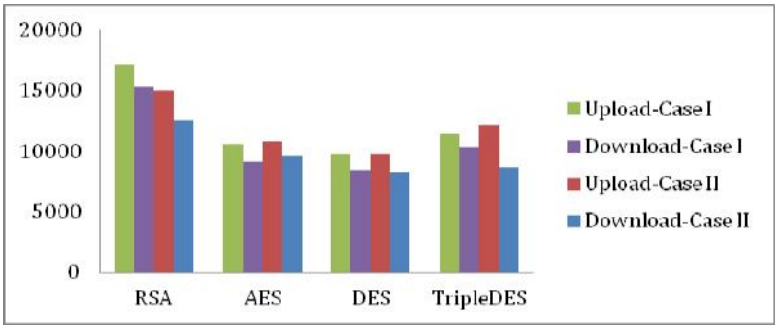

Fig. 14. Graph of the group 2.3

Group 3: The measurements are based on the way of partitioning (random way) and Uploading/Downloading them to the cloud, in the programming we set the minimum partitioning 1 part and the maximum up to 10. Characteristics of the file: the type of file .doc was used with size 606KB. These measurements were obtained for two scenarios, Fig. 7- Case I and Fig. 9- Case II, Table 5.

Table 5. Time measurements for group 3

N	Process	File type	Case	Algorithm	Key - bits	No. partitions	Execution time (ms)
1	Upload	.doc	I	RSA	1024	Random /3	16229
1	Download	.doc	I	RSA	1024	Random /3	11350
2	Upload	.doc	I	AES	128	Random /7	18435
2	Download	.doc	I	AES	128	Random /7	12547
3	Upload	.doc	I	Des	64	Random /4	17901
3	Download	.doc	I	Des	64	Random /4	10271
4	Upload	.doc	I	TripleDES	128	Random /2	13545
4	Download	.doc	I	TripleDES	128	Random /2	9038
1	Upload	.doc	II	RSA	1024	Random /1	12884
1	Download	.doc	II	RSA	1024	Random /1	11520
2	Upload	.doc	II	AES	128	Random /8	20967
2	Download	.doc	II	AES	128	Random /8	15350
3	Upload	.doc	II	Des	64	Random /5	15812

3	Download	.doc	II	Des	64	Random /5	14351
4	Upload	.doc	II	TripleDES	128	Random /3	13039
4	Download	.doc	II	TripleDES	128	Random /3	9718

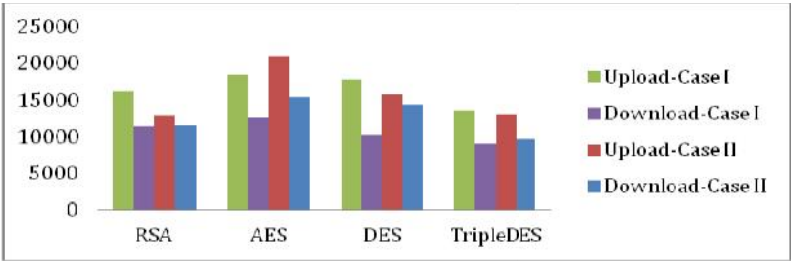

Fig. 15. Graph of the group 3.

Group 4: These group of measurements compare the time of execution of t1 (one part) and t2 (three parts) of partitioning. We consider only .doc file (2969 KB), table 6 for uploading and table 7 for downloading. The t1 was considered as basic time (minimum one) for one partition of the file.

These measurements were obtained for two scenarios, Fig. 7-Case I and Fig. 9-Case II.

Table 6. Time measurements for group 4 (Upload).

Case	Algorithm	Execution time (ms) t1 (Static / 1)	Execution time (ms) t2 (Static / 3)
I	RSA	28416	38009
I	AES	13992	24896
I	DES	14125	28434
I	TripleDES	16264	29234
II	RSA	24970	33607
II	AES	15926	28329
II	DES	14779	29452
II	TripleDES	14813	32039

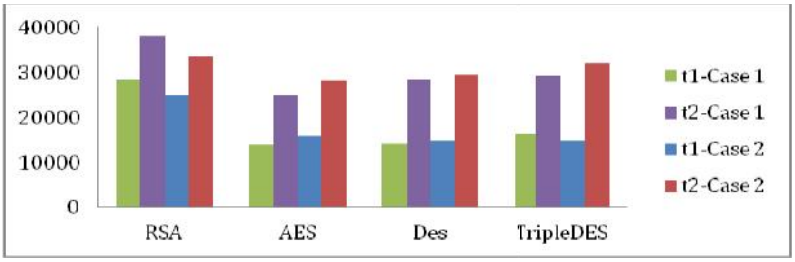

Fig. 16. Graph of the group 4 (Upload).

Table 7. Time measurements for group 4 (Download)

Case	Algorithm	Execution time t1 (ms) (Static / 1)	Execution time t2 (ms) (Static / 3)
I	RSA	7256	33502
I	AES	3647	16644
I	Des	3526	21365
I	TripleDES	4866	24689
II	RSA	9560	30652
II	AES	4003	25100
II	Des	8644	27573
II	TripleDES	3549	30683

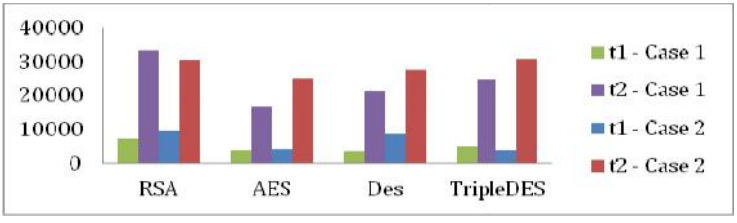

Fig. 17. Graph of the group 4(Download).

7.1 Discussions on obtained measurements, based on our model

Group 1 (large file 2969KB**).** The results reported that for larger size files asymmetric algorithms are not supported because they need much more time to be executed than symmetric algorithms. At the groups of faster algorithms results to be the symmetric algorithm AES, in the meantime this algorithm is faster for case I and the download mode.

Group 2 (different type of files: .doc, .pdf, .png). The results reported that the types of files do not have any effect on the results, almost at the three measurements we have achieved similar results, as in group 1. Therefore,

symmetric algorithms are faster comparing to asymmetric algorithms and the AES is the fastest one.

Group 3: At this group of measurements we used general characteristics of measurements such as group 1 and 2, but the focus was the random way of partitioning (Case I and II). Based on the results it is also seen that there is no exact classification which from options could be the best because we are completely depended on the number of segments.

Group 4: from the group 4 seem to be the same tendencies as in group 1 regardless the file was divided in one partition (t1) or in three partitions (t2).

8. CONCLUSION

The model here proposed was based on the Thales e-Security, (2017) as it offers a security- controlled system from the ITSS of the organization. The model has different scenarios. In addition, some testing cases and information generated the file "~..enc" for the strategy used in the proposed model are here reported and provided.

The last part of this paperwork provides obtained measurements of different characteristics and comments for every measurement group. Based on the measurement results the fastest algorithms for large size files are the symmetric ones.

Therefore, the AES algorithms belong to the group of symmetric algorithms.

Even though different ideas exist about security in the cloud, the proposed model offers the possibility of controlling security by the ITS Specialist, (Hyseni *et.al*, 2015; Hyseni *et. al*., 2016), controlling the security in the cloud based on different options.

Measurements for the other types of the files will further, with the possibility of completing measurements for the other scenarios including hybrid algorithms and different working environments.

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SCIENTIFIC INFORMATION

MECHANISMS OF ELECTRON TRANSFER IN BIOSTRUCTURES

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ABSTRACT

A brief and oversimplified formulation of theoretical analysis of electron transfer reactions in biostructures is here reported. Electron transfer reactions are of irreplaceable importance for many biological transformations—from photosynthesis to aerobic respiration. The dynamic processes in the physiology of photosynthesis, focused on molecular mechanisms of photosynthesis is here investigated. First, a combination of general outlook and specific considerations by starting with some general physical principles is here introduced. Second, the theoretical framework is expanded with details from the structure of the complex, related with the pathway and kinetics of the electron transfer processes. The paper reports that the nuclear system of macromolecules is characterized by a wide range of different types of intramolecular motion. Here, the mechanisms of electronic transition, including the electron transfer or the migration of electron bulging energy is of great interest as the interaction with vibrational degrees of freedom occurs. It is a means to address the mechanism of electron-conformational interactions underlying the functioning of biomacromolecules.

***Keywords*:** electron transfer reaction, photosynthesis, dissipative processes, biostructures

1. INTRODUCTION

The theory of electron transfer (ET) reaction relates to the chemical and biological physics, meanwhile the biological electron transfer reactions have been the subject of a great deal of both experimental and theoretical analysis in a wide range of systems (Marcus and Sutin 1985; Moser *et al*., 1992; Bendall 1996; Gray and Winkler, 1996), from photosynthesis to aerobic respiration.

Photosynthesis is a biological process whereby the Sun's energy is captured and stored by a series of events that convert the pure energy of light into the biochemical energy needed to power life, ATP (Adenosine Triphosphate) (Blankenship 2014). Absorption, transformation and conservation of energy in the process of photosynthesis is defined as series of

the following processes: i) absorption of light and energy transfer through the pigment antenna to the active centres, ii) transport of electrons (primary charge separation in active centres and electron transfer from the excited pigment of the reaction centre to the acceptor, pheophytin), iii) stabilization of the energy of "excited" electrons with the help of oxidation-reduction reactions (photosynthetic electron transport) and synthesis of ATP (Adenosine Triphosphate) and, iv) synthesis and export of stable products of photosynthesis.

All chlorophyll-based photosynthetic organisms contain light-gathering antenna systems. The molecule of chlorophyll which locates in the antenna of the light-harvesting complex II (LHCII) absorbs a Photosynthetically Active Radiation (PAR) photon, is called excited molecule. The valence electron in the pigment molecule passes from the initial to the higher energy level. The excited molecule of chlorophyll (X_1) transmits the excitation energy to neighbouring molecules of chlorophyll (X_2) by resonance and returns to the ground state. A necessary condition for such a mechanism for transfer of excitation energy is the location of the maximum of the absorption spectrum of the molecule X_2 in the longer-wave part of the spectrum compared with the maximum for X_1. This transfer is always associated with the loss of energy (David and Krishna 1999). The smaller the distance between the pigment molecules where the transmission process of excitation energy occurs, the higher the probability of transport.

Light-gathering antenna systems function to absorb light and transfer the energy in the light to a trap, which quenches or deactivates the excited state (Blankenship 2014). The trap is the reaction centre itself, and, in most cases, the excited state is quenched by photochemistry with energy storage. In some cases, the quenching is by other process, such as internal conversion or fluorescence.

Migrating through the antenna, the energy is transferred to the chlorophyll molecule in the photosynthetic reaction centre P680, and the excited electron from chlorophyll passes to the acceptor - pheophytin (FeO). Once the primary separation of the charges occurs, a radical pair ($P680^+$ - FeO^-) could be created.

Reaction centre complexes are integral membrane pigment–proteins that span the membrane in a vectoral fashion. These complexes are the nuclei of photosynthesis. All reaction centres of photosynthetic complexes carry out light-driven electron transfer (ET) reactions, resulting in charge separation across the membrane. In addition, some reaction centres also pump the protons which are coupled to the electron transfer reactions involving quinones.

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(PAR) photon, is called excited molecule. The valence electron in the pigment molecule passes from the initial to the higher energy level. The excited molecule of chlorophyll (X_1) transmits the excitation energy to neighbouring molecules of chlorophyll (X_2) by resonance and returns to the ground state. A necessary condition for such a mechanism for transfer of excitation energy is the location of the maximum of the absorption spectrum of the molecule X_2 in the longer-wave part of the spectrum compared with the maximum for X_1. This transfer is always associated with the loss of energy (David and Krishna 1999). The smaller the distance between the pigment molecules where the transmission process of excitation energy occurs, the higher the probability of transport.

The chemical properties of an excited molecule may be very different from those of the same molecule in the ground. Particularly, the oxidation–reduction potential for electrons, either being added to the molecule or given up by it, is very different in the excited state compared with the ground state. The result is that the excited molecule is an extremely strong reducing agent, which readily gives up an electron to a nearby electron acceptor molecule. This excited state of the ET process is the first photochemical process of photosynthesis and the light energy transforms into chemical energy.

At the end, an oxidized dimer of chlorophylls and a reduced electron acceptor molecule could be obtained. The primary ion pair state consists of the oxidized, and now positively charged, dimer and the reduced, and now negatively charged, acceptor. It is, however, a highly unstable system, and the energy is easily lost if it is not stabilized by subsequent secondary processes. Once the primary electron transfer process occurs, the system could be poised at a critical juncture. The oxidized primary electron donor is positioned next to the reduced acceptor. Based on the thermodynamics laws, the electron might simply transfer back to the donor. This recombination process results in the conversion of all the energy of the photon to heat, without the opportunity for any to be stored. Ultrafast series of secondary electron reactions separate the oxidized and reduced species to allow the energy to be stored. The result is that the positive and negative charges are separated from each other, and the chances of recombination have greatly reduced. If the secondary stabilization reactions are much faster than the recombination process, most of the complexes would avoid recombination and stable products could be produced. Therefore, the focus is on the first few reactions following excitation of the special pair.

Following excitation of the special pair, the excited state of P870 has a lifetime of about 3 ps at room temperature, decreasing to about 1 ps at cryogenic temperatures. This excited state ($P870^*$) is conveniently monitored by measuring stimulated emission in the 900 nm region. The $P870^*$ excited state is a very strong reductant, with an estimated excited state redox potential

of -940 mV vs NHE. It decays primarily by losing an electron to become the cation radical $P870^{+}$.Whenever a pigment is excited or either gains or loses an electron, its ground state absorption bands bleaches. New absorption bands that are characteristic of the excited, oxidized or reduced species will appear at the same time as the ground state bands bleach. Analysis of these spectral changes helps elucidate the electron transfer pathway.

The reaction centre carries out photochemistry and some early stabilization reactions, but additional processes must be carried out prior to the long-term energy storage. Here, the electron transport chain would be of primary importance.

Stable electron carriers on the acceptor and donor sides of the photosystem II (PhSII) are far apart, which prevents the possibility of recombination of separated charges, and this is a prerequisite for the effective use of the electron excitation energy stored by the PhSII in the subsequent stages of photosynthesis (Jones and Fyfe 2001).

Thus, the initial sequence of redox reactions leads to the transfer of electrons through their further carriers with an increasing redox potential.

Pump operation increases the proton concentration gradient on the thylakoid membrane, which is the driving force of the ATP synthesis process (Kramer *et al*.,2004).

Electron transitions are an important class of chemical and biological reactions. The theoretical description of biological ET has grown out of the pioneering work of Marcus (1965) and Marcus and Sutin (1985) on inorganic reactions in solution. Marcus (1965) reported about the theory for treating the rates of outer-sphere electron-transfer reactions. Here, he derived several very useful expressions, one of which is known as the Marcus equation. In addition, the electron-transfer theory to several systems of biological interest was applied. Moreover, he established that various factors, in particular, quantities such as the standard free energy of reaction, the reorganization energy for vibrational and solvational changes, the separation distance r, and the work terms (e.g., coulomb interactions), affect the rate of the electron-transfer reactions Marcus (1965).

The ET process can be viewed as a nonradiative relaxation process from an initial state with the electron donor (D) reduced and the acceptor (A) oxidized to a final state with the donor oxidized and the acceptor reduced, according to:

$$D_{r} + A_{o} \rightarrow D_{o} + A_{r}$$

Meanwhile, the theoretical formulation for energy transfer, that is clearly applicable to weakly coupled pigments of photosynthetic systems is the Förster mechanism. This Förster energy transfer mechanism is a nonradiative resonance transfer process. The energy transfer process becomes one of the many possible decay processes.

In the electron transfer reactions, the Fermi golden rule describes the first-order rate constant for the electron transfer process, as discussed below. The result is in many ways similar to the Förster theory of energy transfer (Blankenship, 2014). An initial state where the electron (or the excitation) is localized makes a nonradiative transition a final state in which the electron (or excitation) has moved to another molecule. The difference between the exponential distance dependence of electron transfer and the inverse sixth power distance dependent upon the Förster energy transfer process could be met. This difference happens because the electron transfer is mediated by coupling that reflects the overlap of the wave functions of the reacting species, which characteristically fall off in an exponential manner, whereas the Förster process is mediated by a dipole–dipole coupling interaction.

The electron transport can occur at relatively large distances, regardless the translational motion of the donor and acceptor molecules of the electron. Consequently, these processes could be distinguished from oxidation-reduction reactions in solution. Meanwhile, the semiconductor concept has not been confirmed in biological systems (although, there are some modifications to this model). Currently, the electron tunnelling between individual protein molecules - vectors separated from each other by energy barriers is of the greatest interest. The most important feature of the above-barrier electron transport along the tunnel mechanisms is occurrence even at low temperatures (liquid-nitrogen temperatures of 77K). Under these conditions, the translational motion of large protein molecules has slowed down. Consequently, the usual physicochemical mechanisms of reactions in solutions of the type of colliding parts possessing excessive kinetic energy is unachievable at a high rate. In this way, the tunnelling mechanism can ensure the transfer of electrons under conditions when the Arrhenius reaction-activated reactions “do not work”, which eliminates the effective tunnelling of electrons and at normal temperatures that successfully competes with the usual “activation” reactions.

Tunnel transfer of an electron does not require large-scale displacement of whole molecules but is accompanied by changing the equilibrium energy configuration of the system due to changes in the charges of the state of molecules and the transition of the system to another potential energy surface. In photosynthetic RC it is manifested in the form of the dependence of the nature of the transfer on the conformational state of the protein components of the RC. This transfer is also associated with conformational changes in protein components.

According to various estimates, the distances between the active prosthetic groups of vectors directly transmitting an electron are not less than 0,5 – 1 nm.

In the low-temperature region, where the electron transfer is practically independent of temperature, the corresponding reorganization of the nuclear system should also occur without activation. This means that the nuclear configuration also changes due to tunnelling through a barrier formed by the intersection of potential surfaces.

The nuclear system of macromolecules is characterized by a wide variety of different types of intramolecular motion. The mechanisms of electronic transition, including electron transfer or migration of electron excitation energy, interaction with vibrational degrees of freedom is of great interest.

Intramolecular processes, accompanied by transitions by electrons, requires for its description an apparatus of quantum mechanics (Rubin, 2004).

2.Transport in a two-level system

We consider the donor's and the acceptor's initial state, in the system DA, as electro neutral and in basic electronic state. Because of excitations, the donor molecule or electron annexed to it from the external system, results in nonstationary state. Meanwhile, due to the interaction between donor and acceptor, transition between initial (i) and final (f) states according to the following scheme occurs:

$$i \longrightarrow f, \quad (D * A) \rightarrow (DA *).$$

Transitions i → f may be accompanied by the perestroika of the nuclear equilibrium configuration in the system (DA). The dependence of probability of transition upon the interaction characteristics, system parameters and external conditions (temperature) is here investigated.

Let D and A be two identical atoms with two energy levels, and the donor and acceptor states be described by the wave functions φ_D and φ_A in the lower unexcited state, respectively. The upper states correspond to the functions φ'_D and φ'_A. We assume that at the initial moment t = 0. The system is in the state D′A with the wave function $\psi_i = \varphi'_D\varphi_A$. Because of the interaction between the donor D_1 and the acceptor A, can occur a transition to a state that can approximately be described by the wave function $\psi_f = \varphi_D\varphi'_A$.

According to the principle of superposition in the two-level approximation, the total wave function of the DA system has the form:

$$\psi = C_i(t)\,\psi_i + C_f(t)\,\psi_f$$

here, the coefficients C_i (t) and C_f (t) depend on time, whereas the square of their module determines the probability of finding in the respective states i and f.

The initial state of the system in the absence of the interaction between D and A is described by the wave functions ψ_i and ψ_f:

$$\psi_i = \psi_i^0 \exp\left(-i\frac{E_i}{\hbar}t\right) = \psi_i^0 \exp(-i\varpi_i t) \qquad (1)$$

$$\psi_j = \psi_f^0 \exp\left(-i\frac{E_f}{\hbar}t\right) = \psi_f^0 \exp(-i\varpi_f t)$$

To find the coefficients $C_i(t)$ and $C_f(t)$ in the presence of interaction, we must solve the nonstationary Schrödinger equation:

$$i\hbar\frac{\partial\psi}{\partial t} = (\hat{H}_0 + \hat{U})\psi \qquad (2)$$

and can obtain two equations for finding the coefficients $C_i(t)$ and $C_f(t)$. Suppose $\omega_i = \omega_f$:

$$i\hbar\frac{\partial C_i}{\partial t} = V_{if}C_f,\ i\hbar\frac{\partial C_f}{\partial t} = V_{if}C_i \qquad (3)$$

$$V_{if} = \int \psi_i^* \hat{U}\psi_f dt \qquad (4)$$

here, V_{if} element interaction matrix.

The solution of equation (2) allows to determine $|C_i|^2$ and $|C_f|^2$, i.e., the probability of finding the system in the states ψ_i and ψ_f under the initial conditions $C_i(0) = 1$ and $C_f(0) = 0$:

$$|C_i(t)|^2 = \cos^2\left(\frac{|V_{if}|t}{\hbar}\right)$$

$$|C_f(t)|^2 = \sin^2\left(\frac{|V_{if}|t}{\hbar}\right) \qquad (5)$$

Clearly, in a two-level system with resonant levels, quantum - mechanical oscillations occur between the states i and f or the electron exchange between D and A with frequency $2\frac{|V_{if}|}{\hbar}$. The solution of a more general problem for ω_i

$\neq \omega_f$ leads to a similar result, and the amplitude of the oscillations remains of the order of unity, if the condition is satisfied:

$$\left| \omega_i - \omega_f \right| \leq \frac{|V_{if}|}{\hbar}$$

This means that the resonance condition is preserved if the energy levels of the initial and final states $E_i = \hbar\omega_i$ and $E_f = \hbar\omega_f$ coincide with accuracy to the interaction energy causing the transition.

If

$$\left| \omega_i - \omega_f \right| >> V_{if}\ \hbar$$

then amplitude of the oscillation $\left| C_f \right|^2$ becomes of the order

$$\left| V_{if} \right|^2 / \hbar^2 (\omega_i - \omega_f) \ll 1$$

and the transition $i \rightarrow f$ practically does not occur.

In the system of two discrete levels, even in the presence of resonance cannot be implemented, the irreversible ET or energy. Here, quantum-mechanical beats arise between the states i and f, which does not allow clearly fixing in the acceptor the excitation energy or the electron. To ensure the irreversibility of the transfer need to inclusion of some dissipative processes, during which a part of the excitation energy (electron) is scattered during the time in the acceptor. If this leads to a "detuning" of the resonance levels in the acceptor and the donor in a time, less than $\hbar/2 \left| V_{if} \right|$, then the reverse transfer from the acceptor to the donor molecule becomes practically impossible; hence, the irreversibility of the transition is due to the coupling between the dynamic (electronic) and dissipative systems under consideration.

3.Tunnel effect

3.1. Mechanism

Physical representations connected with the problem of tunnelling of electrons or nuclei are important for the further presentation. Tunnelling is the process, possible in quantum mechanics, whereby a particle can disappear from one side of a potential energy barrier and appear on the other side without having enough kinetic energy to mount the barrier. This can be considered as a manifestation of the wave-nature of the particles. If a particle is lighter, the wavelength is larger. In particular electrons, being very light compared to atoms, have wavelengths as large or larger than atoms at energies found in the valence shells of molecules (De Vault, 1980).

The electron in the region I (figure 1, left) has energy E, less than the energy of the potential barrier U_0, which separates the region I from the region II. According to classical physics, the probability that an electron overcomes the region of the II will pass through the potential barrier is zero. In quantum mechanics, the motion of an electron is described by a wave function ψ (x, t), which, like a plane wave falling on the potential barrier U_0, at the point x_0, is partially reflected and partly passes through it.

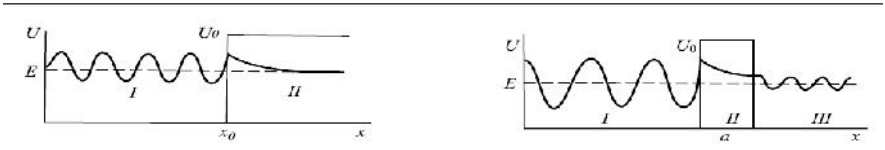

Fig.1: (left) Penetration of an electron under a potential barrier of height $U_0$from the region I in the region of II; (right). Tunnelling of an electron through a finite potential barrier U_0 from region I to region III (Rubin, 2004).

Stationary Schrödinger equations for regions I and II:

$$\frac{d^2\psi_1(x)}{dx^2} + k_1^2\psi_1(x) = 0 \qquad (6)$$

$$\frac{d^2\psi_2(x)}{dx^2} + k_2^2\psi_2(x) = 0$$

The wave function of the system and its first derivative must be continuous throughout the entire region of motion. For I areas:

$$\psi_1(x) = A_1 \exp(ik_1x) + B_1 \exp(-ik_1x) \qquad (7)$$

where exp (ik_1x) corresponds to a wave that runs along the x axis to the barrier from the left to the right, and exp ($-ik_1x$) describes the reflection from the barrier wave.

In areas II, for $(E - U_0) < 0$, coefficient $k_2 = ik$, where

$$k = \sqrt{2m(U_0 - E)}/\hbar$$

The solution of the Schrödinger equation for the region II acquires the form:

$$\psi_2(x) = A_2 \exp(-ik_2x) + B_2 \exp(ik_2x) = B_2 \exp(ik_2x) = B_2 \exp(-kx) \qquad (8)$$

here for a sufficient width of the barrier, owing to the boundary conditions, we can neglect the increasing exponent $A_2\exp(kx)$. The probability of finding the particle at a point x of the II classically inaccessible region is equal to:

$$\left|\psi_2^2\right| = B_2^2\exp(-2kx) = B_2^2\exp\left[-2x\sqrt{2m(U_0 - E)}/\hbar\right] \qquad (9)$$

In the cases when the classically resolved regions of an electron are separated by a barrier (figure 1, right) and the region III is infinite and separated from region I by a barrier of finite width and height, it is possible to determine the probability T of finding the electron in the region III, which is proportional to $\left|\psi_a\right|^2$ and, for ka >> 1, is:

$$T = \exp(-2ka) = \exp\left[-2a\sqrt{2m(U_0 - E)}/\hbar\right] \qquad (10)$$

The quantity T determines the transparency of the barrier. If an electron performs oscillatory motions in a potential pit, hitting on its wall with certain frequency (ω), then the probability of its exit from pit per unit time, is: $W_0 = \nu T$ or

$$W_0 = \nu\exp\left[-2a\sqrt{2m(U_0 - E)}/\hbar\right] \qquad (11)$$

3.2. Attenuation state

The time dependence of the wave function upon the stationary state of the electron in pit is defined as:

$$\psi(x,t) = \psi(x)\exp\left(-i\frac{E}{\hbar}t\right) = \psi(x)\exp(-i\omega t) \qquad (12)$$

When the decay processes are considered, the probability of finding an electron in the pit must be exponentially damped in time, i.e. the wave function in this case must have the form

$$\psi_1(x,t) = \psi_1(x)\exp\left(-i\frac{E}{\hbar}t\right)\cdot\exp\left(-\frac{W_0}{2}t\right) \qquad (13)$$

$$\text{or,}\quad |\psi_1(x,t)|^2 \sim \exp(-W_0 t) \qquad (14)$$

According to the uncertainty relation for energy natural width of the energy level Γ of the electron in the pit related to its lifetime in it ($\tau = 1/W_0$) as: $\tau\Gamma \sim \hbar$.

Thus, the quasi-stationary state of an electron possesses a mean energy E_0 at the level width determined by the decay rate W_0.

Expression (13) can be given a form that corresponds formally to the stationary state by introducing a complex energy $\tilde{E}$, the imaginary part of which characterizes the decay rate, or the level blur about the mean value E_0: $\tilde{E} = E_0 - i\,\hbar W_0/2 = E_0 - i\Gamma/2$.

$$\tilde{E} = E_0 - i\hbar\frac{W_0}{2} = E_0 - i\frac{\Gamma}{2} \qquad (15)$$

We have: $$\psi(x,t) = \psi(x)\exp\left(-i\frac{\tilde{E}}{\hbar}t\right) \qquad (16)$$

The use of the complex energy $\tilde{E}$ instead of the energy of the level E_0 makes it possible to automatically consider the quasi-stationary state or the presence of dissipative processes in calculating the transition probabilities. In the case of dissipative processes, a discrete level with energy E_0 is smeared into a zone characterized by a level density distribution function in the quasi stationary state ρ(E). The density of the levels ρ(E) is directly related to the law of decay of the state. In the case of exponential damping, ρ(E) is the Lorentz distribution with width proportional to the decay rate:

$$\rho(E) = \frac{\Gamma/(2\pi)}{(E-E_0)^2+\Gamma^2/4} = \frac{W_0/(2\pi)}{(\varpi-\varpi_0)^2+W_0^{\,2}/4} \qquad (17)$$

4.Transitions in a two-level system in the presence of dissipative processes

In the process of transfer between two states separated by a potential barrier, in such a system, in the absence of dissipative processes, quantum mechanical oscillations occur between two states Ψ_i and Ψ_f. However, if the final state is quasi-stationary by virtue of certain dissipative processes and is characterized by the complex energy $\tilde{E}_f=\omega_f - i\Gamma_f/2$, then the solution of the system of equations shows that the process of transition from the initial state to the final state is irreversible. This means that can introduce the transition probability per unit time W_{if}, which is determined by the formula (the Fermi golden rule, which describes the first-order rate constant for the ET process):

$$W_{if} = 2\pi\,|V_{if}|^2\,\rho_f(E_i)/\hbar \qquad (18)$$

The probability of a transition between the states Ψ_i and Ψ_f is proportional to the square of the modulus of the matrix element

$$V_{if} = \langle\psi_i|\hat{V}|\psi_f\rangle = \int \psi_i^{*}\,\hat{V}\psi_f d\tau \qquad (19)$$

and the level density in the final state ρ_f, for an energy, equal to E_i. The quantity $\rho_f(E_i)$ in the case of a quasi- stationary state is determined by (17), where instead of E_0 it is necessary to take $\hbar\omega_f$, and Γ_f instead of Γ.

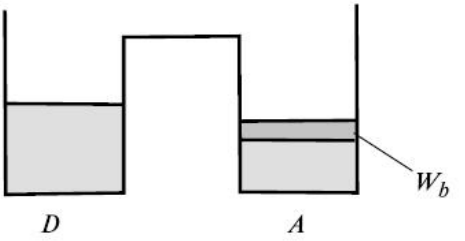

Fig.2: Tunnelling into an electron from the initial state to a metastable level of the final state.

In the case of the tunnelling of an electron between D and A and the consequent fall of the whole system to a final state Ψ_f, accompanied by an irreversible dissipation of a part of the energy or by the escape of the system from the state Ψ_f with the velocity W_b (figure 2), the width of the level of the final state is $\Gamma_f \sim \hbar W_b$. The level broadening can occur due to processes of further electron tunnelling through barrier walls to the nearest acceptor environment. Other processes leading to a broadening of the E level are related to the influence of the environment interacting with the electrons, which leads to a "jitter" in the energy level and loss of coherence with the state of the wave function $\Psi_1(x, t) = \Psi(x) \exp(- i\omega t)$, due to its own phase of oscillations. The broadening of electronic levels in complex molecules can be achieved because of the motion of nuclei and electronic-vibrational interaction, leading to a loss of part of the electron energy in vibrational degrees of freedom. The total width of the level is defined as:

$$\Gamma_f \sim 1/(2T_1) + 1/T_2 \qquad (20)$$

here, T_1 is the characteristic time for further electron tunnelling from the acceptor or the relaxation time of the electron energy; T_2 is the phase failure time due to the motion of the nuclei. As a rule, $T_1 << T_2$, therefore the probability W_b is mainly related to electron-vibrational interactions in vibrational relaxation in the acceptor.

5.Electron-vibrational interactions in molecules

5.1. The role of the motion of nuclei

Up to now, electron tunnelling has been considered at constant values of the energy levels E_i and E_f. In real molecules, it is necessary to consider the state of the nuclei, in the motion of which the energy levels of the electrons change. Modern theoretical ideas on the mechanisms of electron-vibrational interaction could be found in (Levich and Dogonadze1961; Marcus1965; Jortner 1976). The motion of the nuclei regarding the motion of the electron has the character of slowly varying external conditions, to which the electron has time to "adjust" for a time much shorter than the characteristic time of the motion of the nuclei. In the first approximation, the dynamics of the molecular system can be regarded as the motion of electrons in the summary Coulomb field of nuclei whose positions are strictly fixed in space. In this case, the electron energy U and the wave function are parametrically dependent on the internuclear distances R. The Schrödinger equation for electrons has the form:

$$\hat{H}_e \varphi_k(r,R) = U_k(R)\varphi_k(r,R) \qquad (21)$$

Its solution leads to a set of stationary wave functions (r - coordinates of the electrons)

$$\Phi_k = \Phi_k(r,R) \qquad (22)$$

and the corresponding eigenvalues $U_k(R)$. The energy of the molecule in this approximation, $U_k(R)$ includes the kinetic energy of all the electrons T_r, the potential energy of the Coulomb interaction of the electrons with each other (U_{rr}), with the nuclei (U_{rR}) and the nuclei with each other (U_{RR}).

Different nuclear configurations correspond to different electronic energies $U_k(R)$ for a given electronic quantum number k. Consequently, the functions $U_k(R)$ have the meaning of the potential energy for the motion of the nuclei in a given electronic condition.

The Schrodinger equation for determining the energy of the entire molecule and the wave functions of the nuclei moving in the field $U_k(R)$ has the form:

$$\left[\hat{T}_R + \hat{U}_k(R)\right]\chi_{k,n}(R) = E_{k,n}\chi_{k,n}(R) \qquad (23)$$

It follows from (23) that the total energy of the molecule $E_{k,n}$ depends on the electron quantum number k and on the vibrational quantum number n. It includes the potential (electronic) energy of the molecule $U_k(R)$ and the

kinetic energy of the nuclei T_R. The wave function $\chi_{k,n}(R)$ describes the vibrations of the nuclei for a given (k) electron term, $U_k(R)$, and depends, respectively, on the quantum numbers determining both the electronic (k) and nuclear (n) states of the molecule.

The total wave function of the molecule in the Born-Oppenheimer approximation for the separation of nuclear and electron wave functions, considered here has the form:

$$\Psi_{k,n}(r,R) = \Phi(r,R)\chi_{k,n}(R) \qquad (24)$$

5.2. Electronic transitions

Between the initial Ψ_i, and the final Ψ_f state of the molecular system DA, characterized by wave functions of the type (24), electronic transitions must be considered with allowance for the nuclear degrees of freedom.

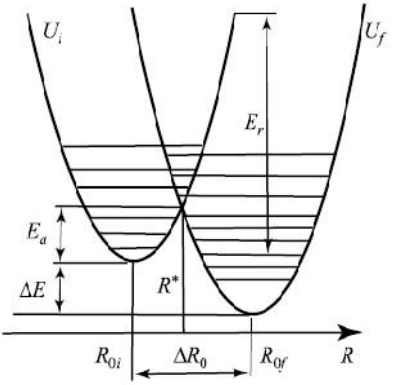

Fig.3: Electron - vibrational interactions in electron tunnelling (according to Marcus):E_0 is the activation energy. The energy of reorganization, ΔE is the thermal effect of the tunnelling process. ΔR_0 is the displacement of the equilibrium position of the nuclei in the transition from the electronic state i to the state f.

A qualitative point of view of the transition (figure 3) is:

$$\Psi_{k,n}(r,R) \longrightarrow \Psi_{k',n'}(r,R) \qquad (25)$$

Suppose that the surfaces U_i and U_f are parabolas corresponding to harmonic oscillators with the same frequencies ω, i.e., we assume that during the $\Psi_i \rightarrow \Psi_f$ transition, the frequency of the oscillations of the nuclei does not change; their equilibrium configuration $R_{0i} \rightarrow R_{0f}$ changes only. The

displacement value ΔR_0 characterizes the relationship between the electronic and nuclear degrees of freedom. In the case of strong coupling, the relation $\Delta = \Delta R_0 / a_0 >> 1$, is satisfied, where a_0 is the amplitude of zero-point oscillations. If the system, due to the motion of the nuclei, reaches the point R* of the intersection of the terms U_i and U_f, where the electron energies of the initial and final states are equal

$$U_{k,n}(R^{\square}) \square U_{k',n'}(R^{\square}) \qquad (26)$$

then a resonant electronic transition is possible because of the interaction determined by the electronic matrix element V_{if}. In this transition the energy of the system does not change, i.e. near R* without additional energy, an electronic wave function can restructure, which changes abruptly from $\varphi_{(i)k}(r, R)$ to $\varphi_{(f)k}(r, R)$. The probability of a transition of the electron in the final state to the unit time for $R \approx R^*$ is proportional to the value of $V_{if}/\hbar$.

Always when a molecule by absorbing a photon makes a jump from the ground electronic state to an excited state, or by emitting a photon makes a downward transition, the distribution of electrons changes instantaneously. The nuclei do not adjust their positions instantaneously to this new potential energy function, because they move much more slowly than the electrons. There is a difference in time scales of motion, the transition is described as "vertical" with the electronic change taking place while the nucleus is in effect "frozen" during the transition. The vibrational state populated by an absorption is usually not the lowest-energy vibrational level of the excited state, because of the horizontal displacement of the two electronic states and the vertical nature of the electronic transition. In a collection of molecules there will be a distribution of populations of the final vibrational states that essentially reflects the probability of the nuclei being in that position. Because the transition involves changes of both vibrational and electronic states of the molecule, it is often called a vibronic transition. The probabilities of transition to each vibrational state of the excited state are called Franck–Condon factors. This term includes effects of temperature and the free-energy change of the reaction and it is difficult to calculate, although simplifications are available. A useful way to describe the Franck–Condon factor is by means of the reorganization energy, Er (Blankenship 2014).

The Franck–Condon principle is a rule in spectroscopy that explains the intensity of vibrionic transitions, which are the simultaneous changes in electronic and vibrational energy levels of a molecule due to the absorption or emission of a photon of the appropriate energy. Classically, the Franck–Condon principle is the approximation that an electronic transition is most likely to occur without changes in the positions of the nuclei in the molecular entity and its environment. The resulting state is called a Franck–Condon

state, and the transition involved, a vertical transition. The quantum mechanical formulation of this principle is that the intensity of a vibrionic transition is proportional to the square of the overlap integral between the vibrational wave functions of the two states that are involved in the transition (Franck–Condon) (Condon 1926; Franck Condon 1928).

Based on the Franck – Condon principle, the probability of the transition of the electron - nuclei system from the initial (k, n) to the final (k', n') electronic states should depend on the degree of proximity of the nuclei to the point R*, from wave nuclei functions $\chi_{kn}(R)$ and $\chi_{k'n'}(R)$. If the point R* is in a region that is classically inaccessible to the nucleus, then it can be achieved only by tunnelling the nuclei themselves. Nuclear tunnelling depends on the degree of overlapping of the nuclear wave functions of the initial $\chi_{kn}(R)$ and final $\chi_{k'n'}(R)$ states, which is determined by the overlap integral, the Franck-Condon factor:

$$F_{n,n'}^{k,k'} = \left| \int \chi_{k,n} \chi_{k',n'} dR \right|^2 \qquad (27)$$

and the probability of the transition (3.1) is proportional to the value:

$$W_{i,n,f,n'} \square \frac{V_{ij}}{\hbar} F_{n,n'}^{i,f} \rho_{f,n'}(E_i, n) \qquad (28)$$

In the expression (18), the Franck-Condon factor $F_{n,n'}^{i,f}$ considers the effects associated with the restructuring of the nuclear configuration. After the final term reaches the sublevel n' = n + p, a dissipation of excess vibrational energy occurs with a transition to the lower vibrational sublevels of the final state, within 10^{-12} s. This means that in (28) the density of final states $\rho_{fn'}(E)$ is determined by the Lorentz function with a width that depends on the vibrational relaxation rate of the level f, n' at an energy E, equal to the energy of the initial state E_{in}. If the excess energy ΔE, or the thermal effect of the reaction, goes mainly to the excitation of the vibrational modes R, then the latter are called accepting modes. The change in the electronic state in the transition $D \xrightarrow{e} A$ causes molecular deformation and a shift in the coordinate $R_{0i} \rightarrow R_{0f}$.

As the figure 3 depicts, in the case $\Delta = \Delta R_0 / a_0 >> 1$, as the number n of the vibrational sublevel of the initial state increases, the width of the barrier for tunnelling of the nuclei decreases. At the same time, the height of the barrier is also reduced, equal to the difference in the energy of the terms at the point R* and the corresponding vibrational sublevel of the initial term. Thus, as the numbers of the vibrational sublevels increases in the state i, the transition probability increases, and their population decreases (Rubin 2004; Blankenship 2014).

5.3. Transfer rate constant

It is found by adding the products of the partial values of the transition rates from each sublevel to the probabilities of their populations at a given temperature T. The average transition velocity is defined as:

$$W_{if} = \frac{W_0 + W_1 e^{\left(-\frac{\hbar\omega}{k_B T}\right)} + W_2 e^{\left(-\frac{2\hbar\omega}{k_B T}\right)} + \cdots}{1 + e^{\left(-\frac{\hbar\omega}{k_B T}\right)} + e^{\left(-\frac{2\hbar\omega}{k_B T}\right)} + \cdots} \qquad (29)$$

In the case of strong coupling ($\Delta >> 1$) $W_1 >> W_0$; is visible, the qualitative physical cause of the two-phase temperature dependence of electron tunnelling in the case of strong electron - vibrational coupling. At high temperatures transitions from high vibrational sublevels W_1 predominate, and at low temperatures, tunnelling of the electron is coupled with tunnelling of nuclei from the main vibrational sublevel. Approximately can be considered:

$$W_{if} = W_0 + W_1 \exp\left(-\frac{\hbar\omega}{k_B T}\right) \qquad (30)$$

In the case of one-dimensional parabolic term and the constant oscillation frequency, the explicit view of the dependence of the Franck-Condon factor on n and n + p is given by the exact formula

$$F_{n,n'} = n!\,(n+p)!\,S^p \exp(-S)\left[\sum_{i=0}^{n} \frac{(-S)^i}{i!(n-i)!(p+i)!}\right]^2;\ n' - n = p \qquad (31)$$

where parameter $S = \frac{\Delta^2}{2} = \frac{M(\Delta R)^2\omega}{2\hbar}$ (32)

is the electron – vibrational coupling constant. It reflects the magnitude of the relative deformation of the molecule along the coordinate R of the acceptor mode ω when the electronic state of the system changes due to energy transfer.

The segment E_r is the energy of reorganization of the system. It corresponds to the work that would be required to shift the coordinates of the nuclei from the initial equilibrium state to the equilibrium values of the coordinates of the final state, provided that the system remains on the initial term, and energy transfer does not occur.

$$E_r = k\,(\Delta R_0)2\ /\ 2 \qquad (33)$$

where k - constant of elasticity, $k = M\omega^2$ and $E_r = \hbar\omega S$, i.e. the energy of reorganization also characterizes the rearrangements that occur in the system during the ET.

The activation energy:

$$E_a = \frac{k^2}{2} = \frac{k(\Delta R_0 - R_{01})^2}{2} + \Delta E \qquad (34)$$

$$E_a = \frac{(E_r - \Delta E)}{4E_r} = \frac{(S\hbar\omega - \Delta E)^2}{4S\hbar\omega} \qquad (35)$$

If the frequencies of the vibrations of the nuclei in the electronic transition are still assumed to be unchanged, then in the harmonic approximation we can write the practically exact formula for the transition rate constant:

$$W_{il} = \frac{|V_{il}|^2}{\hbar^2} \exp(-G) \int_{-\infty}^{\infty} \exp\left\{-i\frac{\Delta E}{\hbar}t + G_+(t) + G_-(t)\right\} dt \qquad (36)$$

here:

$$G_+(t) = \sum_j \frac{\Delta_j^2}{2}(\bar{n}_j + 1)\exp(i\omega_j t) \qquad (37)$$

$$G_-(t) = \sum_j \frac{\Delta_j^2}{2}\bar{n}_j \exp(i\omega_j t)$$

G_+ is associated with the excitation of vibrational quanta with frequencies ω, j numbers the normal oscillations of the system; G_- is due to the absorption of vibrational quanta during the electronic transition; $\bar{n}_j$ is the average population of the oscillator with frequency ω_j, at thermal equilibrium, equal to $(\exp[\hbar\omega_j/(k_B T)] - 1)^{-1}$ and $G = G_+(0) + G_-(0)$ (Rubin 2004).

6. The case of strong and weak electron-vibrational coupling

The formula (36) gives a good agreement with the experimental data on the temperature depending of the rate constant. We consider especially the limiting cases of strong ($S >> 1$) and weak ($S << 1$) coupling (32).

6.1. Weak electron-vibrational coupling

This case is realized for intramolecular electron - vibrational relaxation processes in large aromatic molecules that are not accompanied by charge

separation. For S << 1, the calculation of the integral (36) leads to the formula:

$$W_{if} = \sqrt{\frac{2\pi}{\gamma\ E_0\hbar\omega}}\frac{V_{if}^2}{\hbar}\exp\left(-\frac{\gamma\ E_0}{\hbar\omega}\right) \qquad (38)$$

here $$\gamma = \ln\left[\frac{\Delta E_0}{S\hbar\omega(n+1)}\right] - 1$$

As can be seen from (38), the probability of a nonradiative transition in the case of a weak coupling decreases exponentially with increasing number of excited quanta ΔE/ħω. Consequently, the role of accepting modes is played by the most high-frequency oscillations.

Weak coupling case is represented graphically in figure 4(I). Analysis of the expression (38) shows that in this case W_{if} depends little on temperature; this is understandable, since in the case of a weak connection, $W_1 < W_0$.

6.2. Strong electron-vibrational coupling (S >>1)

This case is in the figure 3 depicted. It can be shown that in the case of one acceptor mode (S >> 1)

$$W_{if} = \frac{2\pi V_{if}}{\hbar^2\omega}\left(\frac{(\bar{n}+1)}{\bar{n}}\right)^{\frac{q_0}{2}} I_{q_0}\{2S[(\bar{n}+1)\bar{n}]^{1/2}\}\exp[-(2\bar{n}+1)S] \qquad (39)$$

here q_0- integer close to $\Delta E_0/\hbar\omega$, $I_{q0}(z)$ is the modified Bessel function:

$$I_n(z) = \frac{1}{\pi}\int_0^{\pi}\exp(z\cos\Theta)\cos(n\Theta)\,d\Theta \qquad (40)$$

The temperature dependence of the constant W_{if} is determined by the change in the average population of the vibrational levels

$$\bar{n} = [\exp(\hbar\omega/k_BT) - 1]^{-1} = \begin{cases}\exp(-\hbar\omega/k_BT)k_BT \square\ \hbar\omega \\ \frac{k_BT}{\hbar\omega}k_BT \square\ \hbar\omega\end{cases} \qquad (41)$$

At low temperatures, when $k_BT << \hbar\omega$, $n \rightarrow 0$, there is an activation-free, or tunnelling in the nuclei, region

$$W_{if} = \frac{2\pi}{\hbar\omega}|V_{if}|^2\exp(-S)\,S^{q_0}\frac{1}{q_0!} \qquad (42)$$

On the contrary, in the high-temperature region, where $k_BT>>h\omega$, the Arrhenius dependence is usual in form, although the ET is still tunnel-like:

$$W_{if} = \frac{2\pi V_{if}}{\hbar}\sqrt{\frac{\pi}{Sk_BT\hbar\omega}}e^{-E_a/(k_BT)} \qquad (43)$$

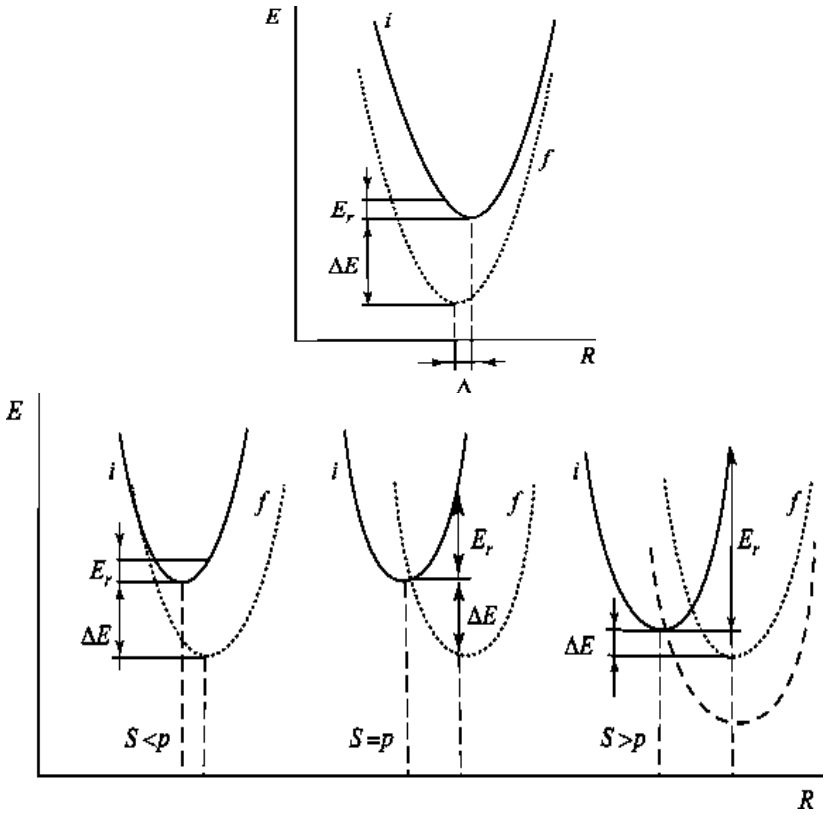

Fig.4. Potential surfaces of the initial and final states in the case of weak (I) and strong (II) electron-vibrational coupling (Rubin 2004).

The figure 4 depicts the paradoxical effect of the accelerated ET reaction occurring as the temperature decreases. The process could be noted in the chain of primary processes of photosynthesis. For a system of electron terms for S > p, the transport process requires a relatively small activation energy. Lowering the temperature can cause such a deformation of the structure of the donor-acceptor pair, so that as a result, the equilibrium positions of the

electron terms will be somewhat displaced, so that the thin intersection of the terms of states i and f can approach the vertex of the parabola i (the dashed curve in figure 4(II) for S> p). In this case, the transfer process becomes nonactivation, and as a result, the ET rate increases with decreasing temperature (Rubin 2004).

In figure 4a, the overlap of the nuclear wave functions of the initial (i) and final (f) states of the donor-acceptor complex is in black depicted.

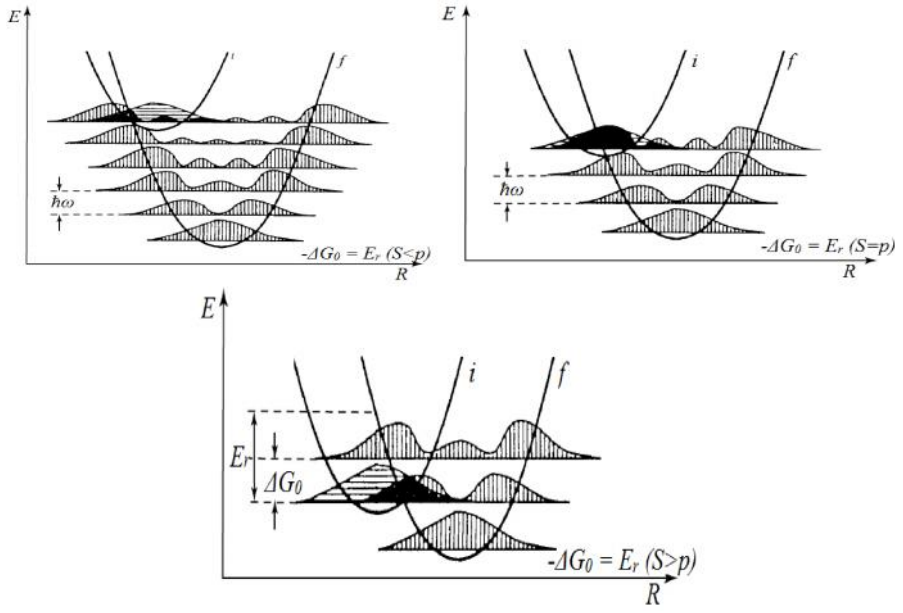

Fig.4a: Overlapping the nuclear wave functions of the initial and final states (Dutton 1992)

The degree of overlap corresponds to the value of the Franck - Condon factor (27). As can be seen, it reaches its highest values at S = p, when the reorganization energy E_r is equal to the thermal effect of the reaction ($-\Delta G_0 = \Delta E$). Blankenship (2014) proved the Marcus theory; that for a given value of E_r, with an increase in the thermal effect ($-\Delta G_0 = \Delta E$), the ET velocity first increases (S<p), reaches a maximum at $-\Delta G_0 = E_r$ (S = p). Once increased at the maximum level, it decreases and ΔG_0 becomes larger than the reorganization energy (S > p).

7. CONCLUSIONS

The native three-dimensional structure is established because of the action of several electrical and entropic factors. The change in the conformational state of the protein molecule due to various external influences (PH, temperature, ion composition) also affects its functionality. Recognition of electron transfer reactions and energy transfer processes is of great importance for understanding stability of the protein structure in the very process of its functioning. In addition, it does not undergo a change directly related to the course of the reaction into which the protein molecule is involved, the inherent conformational mobility of the structure of biopolymers, its nature and functional significance. The problem is of great importance for the sensitive molecular mechanisms of the functional activity of biomacromolecules and the participation of their fundamental biological processes.

The electron transfer reactions in biological systems occur due to: i) the distance between the donor and the acceptor, ii) the standard state free-energy change, iii) the Marcus parameter or the reorganization energy which can be considered to be the amount of energy required to distort the geometry of the reactants into that of the products without the electron transfer actually taking place, iv) the type of proteins and the their structure, v) surrounding conditions and many other factors that are not here considered. In many cases, a simplified picture of the electron transfer process is useful.

The rate of the electron transfer process is represented as primarily dependent upon the distance between the donor and the acceptor. This formulation assumes that the free-energy change of the reaction and the Marcus parameter are equal, so that the process is optimal, and observed rate differences reflect only the distance between the two species that react. It is often found that this is the case, or adjustments can be made to take account of the differences. This view supposes that most proteins are similar enough in dielectric properties to behave in the same way, and the details of the protein structure are averaged away, so that the rate is a function only of the distance between the electron donor and acceptor.

An alternative view emphasizes the detailed structure of the electron transfer proteins and analyses potential pathways that the electron might follow from donor to acceptor. The pathway model can include interference effects between different pathways, which have been suggested to be important in the QA to QB electron transfer process.

Both approaches have advantages and disadvantages and the most appropriate approach is selected based on the precise questions being asked and the system under consideration.

For transfer of an electron over a protein chain, the tunnel mechanism provides an elementary act of ET between donor-acceptor groups, located at about 0.5-1.0 to tens of nanometres from each other and can involve the interaction of different protein molecules.

A characteristic feature of these reactions is that they may be activated at high temperatures and fall to almost constant values at low temperatures. The consideration of environmental effects on electron transfer reactions in complex dynamic systems, is of particular interest. Temperature and the detection-wavelength dependence of the rates of the primary electron transfer reaction can reflect a distribution of reaction centres having the differences in factors such as the distances or the orientations between cofactors.

Despite the structural symmetry, the RC is functionally highly asymmetric. Unidirectionality is the process of the primary charge separation in the reaction centres (RCs). Here, two symmetric ways of electron transfer, starting from the common electron donor are possible.

The limiting stage in the transport process is not the motion of the charge over current states, but the relaxation processes in the donor and acceptor.

For the elucidation of the mechanisms of electron transfer reactions in biological systems, the conformational variations must be incorporated into the model and what is the influence of conformational variations of the system on the quantum tunnelling of electrons in the biological systems.

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ALBANIA IN THE LAST 2 DECADES IN THE CONTEXT OF INFORMATION LITERACY IN LIBRARIES, EDUCATION AND LIFE LONG LEARNING[1]

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OSCE Presence in Albania

ABSTRACT

A research was carried out in 2014 to provide sufficient evidence of: i) the level of knowledge of information literacy (IL) in Albania starting from academic environments and public institutions to the general public and, ii) the policies and practices available from the responsible institutions for improving IL. Findings suggest best practices for publishing and spreading IL; policies and practices that should be applied by central institutions; current practice of libraries. In order to effect an early and thorough change in the perspective of IL polices and strategies from the top down level, the chosen research method was a quantitative survey with a questionnaire as an instrument. The research targets the national level, but was distributed only in Central Albania. The data reported that the government and its bodies, libraries and universities lack an understanding of the concept and use of IL.

[1] Note: This paper/article is based mostly on my thesis for Master in Library Science, full text of the thesis "Information Literacy in Albania : The Role of Libraries in Fostering and Practising Polices of Literacy, Life Long Learning and Information Literacy Education" can be found also here.

There are no national strategies, programs, seminars or IL courses offered or planned to be offered within the various curricula. The concept is often confused with information and communication technology (ICT) and libraries also lack the right infrastructure to support the development of a global knowledge society. Findings and conclusions on the current situation of IL, as it affects the daily life of Albanians, emphasized the importance of IL in the future development of Albanian citizens. The present investigation aims to encourage a national discussion on IL issues as a means to address the needs of state institutions such as the ministries, libraries, universities, and governmental institutions, to prepare 'A National Action Plan' for IL and its future in the country. New library and education strategies and initiatives will be proposed, including the outlining of changes in curricula, support and advancement, in the following document. New realities require new skills to navigate, evaluate and use information. Universities, libraries and library associations, collaborating with other institutions, are crucial in assisting all levels of users in using information properly in professional and daily life decisions
***Keywords*:** information literacy, libraries, Albania, reading, youth, curricula, life long learning

1. INTRODUCTION

This paper is based on the UNESCO workshop run in 2008, in Ankara, Turkey "Training the Trainers in Information Literacy"

Sharing data Public Library of Fier, Albania, about the Information Literacy (IL) addressed the need for new services. The work subsequently begun.

As information about IL lacked in Albania and no official agreement on the translation of the term Information Literacy existed, studies on IL begun.

The Information Literacy Baseline Survey used for this thesis, provided the current understanding of IL in Albania including its libraries' infrastructure and their challenges. It was a means to address the needs and measures and practices, support possibilities and collaboration in IL initiatives sorely needed in Albania to be used in inter-institutional consultation.

Adapting to developments in the "Information Age", rapid development of ICT, internet and web 2.0, mobile devices, fast growth of various digital information sources and services, requires a high degree of IL skills. The 2000 survey of the Organization for Economic Cooperation and Development (OECD), an adult literacy survey (OEDC, 2000) reported, that across 20 countries, one in four adults who participated in the study do not possess the necessary literacy skills to cope in today's world. A reasonable assumption is that the study took place in poorer or less developed countries, but this is not the case. The sample included the USA, Canada, and four Scandinavian countries, Germany, the UK, Ireland, Australia and New Zeeland. Albanians can be included in lacking skills and strategies, causing a gap in knowledge.

1.1 *Some obstacles related to information literacy development*

Education is possibly the best tool we have for tackling poverty. Literacy is at the heart of education, and is a basic human right. When people have the chance to learn basic life and literacy skills, economies grow faster and poverty rates decline (World Literacy Foundation, 2013).

Based on the survey results and the deliberations of the United Nations Educational, Scientific and Cultural Organization - Central European Initiative (UNESCO-CEI) workshop on information literacy, the following conclusions have been drawn regarding the information literacy situation in the region, as given in the next section below (only the part related to the library is quoted) :

"…the challenge is insufficient understanding of the concept and its relevance to today's information society…Moreover; there are specific shortcomings in the library sector. In particular, the position of a librarian engaged in information literacy instruction has not been defined. Where programs are provided, librarians often do the work as volunteers, although these specialized roles require training and need institutional support. This is the only effective way to ensure that information literacy is embedded in curriculum, teaching, learning and assessment throughout higher education. Elsewhere in the world it is already recognized that these roles require training and institutional support. Therefore, further development of library professionals is needed to extend understandings of the role of information literacy in economic development, and to foster understanding of the importance of embedding information literacy within the content of all disciplines" (Workshop on IL initiatives for Central and South East European Countries, 2006).

Albania was involved in this study in 2006. Analyzing the context, data collected in 2012 and the situation in some libraries in Albania today, we will conclude where Albania stands with understanding the concept, strategy, curricula, training or other initiatives related to IL.

2. SURVEY OF PUBLISHED RESEARCH ON INFORMATION LITERACY CON- CEPT, DEFINITION, STANDARDS, RELATION WITH LIFE LONG LEARNING AND PRACTICES

2.1 The information literacy concept, definition and standards

The term 'Information Literacy was first introduced by Zurkowski (1974): "people trained in the application of information resources to their work can be called information literates. They have learned techniques and skills for utilizing the wide range of information tools as well as primary sources in molding information-solutions to their problems".

Information Literacy is the catch phrase for the entire trans-literacy system that includes visual, digital, media, cultural, critical, 21st century workplace, metal, mobile, global etc. literacies. This concept is used in workshops, talks, in many international conferences. The “information age” we are living in and the challenges ahead demand individuals to have more skills.

Information Literacy means the set of skills, attitudes and knowledge necessary to know when information is needed, to help solve a problem or make a decision, how to articulate that information need in searchable terms and language, then search efficiently for the information, retrieve it, interpret and understand it, organize it, evaluate its credibility and authenticity, assess its relevance, communicate it to others if necessary, then utilize it to accomplish bottom-line purposes. Information Literacy is closely allied to learning to learn, and to critical thinking, both of which may be established, formal educational goals, but too often are not integrated into curricula, syllabi and lesson plan outlines as discrete, teachable and learnable outcomes; sometimes the terms “Information Competency,” or “Information Fluency” or even other terms, are used in different countries, cultures or languages, in preference to the term Information Literacy (Horton, 2008).

Quantitatively increasing information renders it important to possess the skills necessary for reaching the required information and using the information effectively in line with the requirements. These skills are discussed in the information literacy concept, and educational institutions are expected to provide individuals with these skills (Bas and Erdem 2013).

There have been different discussions over the recent years related to information literacy standards and the environment to which they apply. These contrary viewpoints concerning standards, which were articulated almost one decade ago are still echoed today, even going to such extremes as to claim that such insistence on standards inevitably leads to over-systematization and the predominance of a certain form of generic rubric and a de-contextualized form of administrative paperwork which entirely disconnects IL from pedagogical theories (Jacobs, 2008 as cited by Spiranec and Zorica).

Librarians are applying these findings by striving to work closely with university administrators and professors to integrate information literacy skills into the student learning process. At the University of Tennessee in Chattanooga, for example, librarians helped write the basic English curriculum, ensuring that the standard course, reaching 78 percent of freshmen, was aligned with ACRL information literacy standards. Today, “students simply cannot pass either semester of freshman composition without meeting a certain minimal threshold of information literacy in accordance

with ACRL standards 1 through 4."(Digital Literacy Task Force, ALA Office of Information Technology Policy, Report, 2013).

2.2 *The information literacy and life long learning*

The Alexandria Proclamation on Information Literacy and Lifelong Learning of November 2005, states that "Information Literacy lies at the core of lifelong learning. It empowers people in all walks of life to seek, evaluate, use and create information effectively to achieve their personal, social, occupational and educational goals. It is a basic human right in a digital world and promotes social inclusion of all nations" (Alexandria Proclamation, 2005).

Information Literacy is inter-related with Lifelong Learning, with the ability to learn the learning process, and to critical thinking, but too often, not only in Albania, they are not yet integrated into curricula. Primarily the education systems, and then the libraries, have another chance to re-evaluate their role and goals in this fast changing environment.

Information and the way how to share it are very impressive from the variety of means, spread of development and cost. The ability to stay in touch 24/7 with family, friends and professionals around the globe is no longer a dream for humanity.

Studying without using ICT is unimaginable today. Students themselves see ICT as a tool that contributes to better study results. However, one should keep in mind that overemphasizing ICT may have negative consequences as well: overwhelming by virtual communication, psychosomatic difficulties, loss of identity and others (Lucie *et al*., 2013).

"The mobile environment has changed the way people interact with information. They access, they evaluate, they use it differently…This is one of the burdens and responsibilities, that we have to help people to use these devices effectively…First we have to become comfortable among ourselves…" (Miller, 2012).

Libraries at all levels have the noble duty to take care of the needs of all the communities they serve. They have to fulfill their tradition role but also create the right infrastructure and programs to accommodate the needs of all age groups and prepare them for the future.

Libraries can capitalize on the current interest in digital literacy while at the same time educating stakeholders as to the broader concepts involved in becoming digitally literate for the long term. In this way, any initiative can have the desired sustainable impact instead of falling short when funding dries up or a new initiative takes its place. Today's public policy emphasis is on workforce development and economic competitiveness. Even when the public policy focus changes, however, librarians will continue their long tradition of helping individuals master the literacies necessary to be active participants in

society (Digital Literacy Task Force, ALA Office of Information Technology Policy, Report, 2013).

2.3 The information literacy practices and findings

There are many examples from some other countries, both at international and regional level. Some of them have been for years in the process of applying Information Literacy standards and strategies along with advanced practices in IL context, some are entering this process and some others are missing it. These practices and findings are not a "how–to-do recipe" but an inspiration and example of how to find the right approaches that may be applied to our conditions, to overcome this challenge fast, as well as a possibility to open a discussion and follow-up policies. Below are some findings during the last 2 decades in some libraries in our country.

2.3.1 ***Examples: Albania***

The experiences of the Public Library of Fier, Albania and of some other institutions from 1995 to date are shared below. They are the first researches published regarding these issues in Albania. Nowadays they are normal and simple activities for many libraries in the region, but they used to be challenging during that time and continue to be so for many public Albanian libraries. Future research may compare the situations and share other practices. The information could be found in (Basha *et al*., 2013).

Opinion survey, Fier Public Library Albania (1995-1996)

From 200 answers received, the average age 25, most readers (70%) wanted to go and find books on the shelves by themselves (the concept "users" and "open access" were not known to the Albanian librarians at that time). Since then, things have changed. In 2000, the library introduced open access to all departments and materials, making the Library of Fier the first public library in Albania to do so. This significantly increased (by 400%) the number of users with library cards, and led to a large number of visitors and users of the new services and activities. Almost every week, local television stations were present to cover the activities.

Introduction of a new service for children and the influence on the number of library users (2001-2002)

The author noticed that the age group of four to six year-olds was not encouraged to visit and use the library. The prevailing concept was that children should register after learning to read. Inspired by the participation in IFLA 1999, ALA 2000, and the study visits in Plum Public Library Chicago, Illinois, and the libraries of Frankfurt Municipalities, the Public Library of Fier introduced "Story Time", an activity involving reading to small children. To avoid the staff's resistance to this very new service, volunteers were

encouraged. A new and attractive corner was built and kindergarten children were invited once a week. The program was accompanied by creative activities. The example was nationally shared and some other libraries also tried to offer it. In 2002, 689 children became part of the reading program and they remained permanent users.

A preference survey in various institutions (2002-2003)

During plans to create a new Information and Training Centre, the Public Library of Fier surveyed users for their information preferences (hard copy or electronic). About 250 questionnaires were distributed and 191 filled in. More than 84% preferred electronic information and they appreciated the idea of the information and training centre in the library. At this time, the internet was used only in few offices for administrative use, by a few lucky families, or in a very small number of internet cafés in the city. The results were presented to the donors. Information and Communication Technology (ICT) infrastructure was offered. We offered open access to all materials in all the departments, which was previously not a norm in our library or others in Albania, and provided eIFL, EBSCO and different information and trainings in ICT. This service, funded by the SOROS Foundation, Library Program, significantly increased the number of library users, especially among youth. Every day, more than 300 people visited the library. This Centre was the next logical step towards the further development of the library.

Survey of all Libraries of Communes and Schools in the Fier Region (2002-2003)

From forty-four schools and commune libraries, only four offered some services and had the space and part-time staff. The survey studied the situation of these libraries after the many changes that occurred in Albania. Another reason was that the Public Library of Fier had many requests from people living outside the city and the library. With its limited staff and number of new books, it could not afford to serve them all. We also wanted to offer training for all the teachers working with the school and commune libraries, who are often language and literature teachers without training in librarianship. After analyzing our data, we invited all district school directors, vice directors, and staff in charge of libraries. They were informed of the new library services and trained to catalogue their books and offer reading programmes.

Who is shaping our opinions? How do we know that our opinions are really our own? (2010)

A survey held for testing one of the IL skills, quality evaluation, and relevance of the information sources. The topic: Is the H1N1 Swine Flu Pandemic True or False?

Findings: 5 of the 6 Employees of an International Organization in Albania think it is false, 1 that it is true. 4 respondents out of 6 think that one of the sources that influenced the choice is media.

As we see, the most popular, relevant source for the respondents is media or consumption of readily-available information that has a great influence in shaping our opinions, even about health. The media and other information providers such as libraries, archives, and the Internet are widely recognized as essential tools for helping citizens make informed decisions…and, therefore, citizens need a basic knowledge of their functions and how to assess them. The purpose of media and information literacy is to impart this knowledge to the users. (MILID Yearbook 2013, p.301).

Library Infrastructure and Staff Training (2012)

The goal of this study was to see where state libraries stand in supporting the new flow of information and ICT developments, as well as how they deliver it to the end users.

Findings: The school libraries serve a community between 700-1700 students and each library has only one part-time employee serving three hours per week. There is no internet or computers available in the library. The internet was available only in one laboratory of informatics. The last acquisition of new materials had occurred more than a year before, and the libraries featured limited titles. Copies could be made only through the General Directorate of Education. The amount of space and number of library reading posts were limited compared to the numbers of students the libraries serve. Annual presentations of library instructions were offered, and usually lasted one hour. Staff is not familiar with IL concepts and has never participated in seminars, conferences, or trainings related to library issues. The library of the local municipality unit has three employees. None of them has training in librarianship. In this library, there is no internet and only one computer. The last book acquisition had occurred four years ago. The university library has two trained librarians. They have two computers in the library, but no internet access. The online databases offered by IZUM through ERA project are used by students through remote access in internet cafés or at home. One librarian was informed about IL concepts during her recent Master Studies in Library Science in Slovenia (Basha *et al*., 2013).

2.4 *Other relevant issues concerning information literacy*

"The pattern of Growth in this field is well established and should be built upon to expand...Such an effort would necessarily create many new opportunities, some of which would be appropriate to the marketplace and others for subsidy" (Zurkowski, 1974).

The **Information for All Program** (IFAP) intergovernmental programme of UNESCO, which promotes universal access to information and knowledge for development of knowledgeable societies, states that information literacy is one of the priority areas for IFAP including ethical, legal and societal implications of ICT and preservation of information. The Thematic Debate on Information Literacy (IFAP, 5 April 2005) specifies that information literacy is concerned with teaching and learning, and it aims to develop critical understanding of information and active participation on information-providing. Therefore, information literacy should be a basic human right in a digital world. It is necessary to communicate and promote the concept of information literacy, to embed information literacy in the curriculum, at all education levels and/or in the professional development and encourage partnerships between teachers and librarians (UNESCO IFAP, 2002).

Solomon and Shrum argued that "we live in a wired globalized world in which communication and collaboration are possible 24/7, where technology is omnipresent. Today's students are no longer the people our system was designed to teach...They may know the technology better, but teachers have to help them use the tools wisely..." (As cited in an IL video prepared by University of Mary Washington, 2009)

Ideally, one should become information literate, and practice those habits and skills over one's entire lifetime. In short, Information Literacy must not be seen as standing alone, as if it were some arcane technical subject that one could learn and then forget about. Also, literacy should not be viewed as a single high point on a scale of learning that can be reached, like scaling a ladder, and then the learner can sit back and feel content and self-satisfied because a personal goal has been reached. Rather, there is no "upper limit" to literacy because it is a continuum, more like a voyage that must be undertaken over one's lifetime (Horton, 2008).

As there are different definitions of Information Literacy, there are also different stages /steps usually described by experts and researchers and this is normal because the paradigm is still new.

Juznic *et al*., (2006) concluded that there should be more public initiatives for promoting the value of the internet to senior citizens. It is important that the librarians are aware of the opportunities they have in establishing these services…Public Libraries should recognize potential users in all age groups. Librarians are there for the sole purpose of helping others in their pursuit of knowledge and better quality of life.

It is obvious that each country will develop and customize its own Information Literacy map to accommodate and "fit" into the unique circumstances with which it is faced. However, having said that, many issues and challenges are quite similar for countries that share similar contexts and

circumstances, since Information Literacy is a context-sensitive phenomenon (Spiranec and Pejova (2010).

Sheldon Shaffer, Director of UNESCO Bangkok 2006, at the preface of the publications "Principles of Awareness-Raising for Information Literacy, a Case Study" (Sayers, 2006) noticed that "any model of awareness-raising, or campaign planning, should be a tool to stimulate discussions and innovations in the design of the process and not a rigid how-to-do recipe. A model can focus on finding optimal combinations of different approaches. Examples of such approaches or modes are public relations (PR), advocacy, personal communication or educational programs in schools".

3. RESEARCH METHOD

3.1 RESEARCH PROBLEM, RESEARCH QUESTION AND PARADIGM

What is Information Literacy for the Albanian Society? ("state of understanding"). Is Albania following International Standards and Indicators? Are IL skills important for future success? Who can train and educate people to gain IL skills? How can Albanian libraries and other Institutions contribute to foster an IL environment?

While in developed countries this concept has been known and understood in professional and intellectual levels for more than 30 years and measures were taken to raise awareness, implement it in the curricula, train librarians, teachers, students and common people, design long term strategies, and share the benefits, Albania is still missing these opportunities.

3.2 HYPOTHESES

For the utilization of IL and the ability to increase its further use, we must first observe and measure the level of knowledge individuals, professionals and institutions have of it. How have they thought of using it? Which are the institutions responsible? And what are the next steps?

As for the questions raised above, the following hypothesis can be deducted from the survey:

1. The level of understanding IL in Albania, not only by the general public, but by a larger group including: academic institutions, libraries, government or media, is low.
2. As there is no official policy regarding IL in Albania, these terms are generally confused with information technology policies.
3. There is no plan in the near future about the application of IL, nor which areas it will be applied to.
4. There is no responsible institution entitled to initiate IL policies.

5. Knowledge resources in IL in universities are low or non-existent. Furthermore, this phenomenon is due to a lack of understanding of the concept of Information Literacy.
6. Libraries offer little or no information regarding IL.
7. Lack of interest in understanding IL and its importance is the main obstacle in Albania regarding Information.
8. Lack of IL curricula in Albanian Education Systems.

3.3 GOALS OF RESEARCH

The research aims to provide sufficient data about: i) level of knowledge of IL in the country, from academic environments and public institutions to the general public and, ii) policies and practices available from the responsible institutions for improving Information Literacy. In addition it suggests: i) best practices for publishing and spreading IL, iii) policies and practices that should be applied by central institutions and, iii) practices of knowledge and information availability of IL from Libraries.

The results identified the needs of Albanians about IL. Solutions will be developed and applications suggested to the government, to non-governmental institutions, libraries, librarians, academic staff, individuals and organizations on how they may collaborate to change curricula, support and develop the roles that school, university and libraries may play in the new information environment and a contribution to lifelong learning.

3.4 METHODOLOGY

The libraries' situation, patterns, education etc. are of great interest. In order to effect an early and thorough change in the perspective of IL polices and strategies from the top down level, we thought of using as our research method the**: Quantitative-Survey, Questionnaire as an instrument.**

3.4.1 Information Literacy Baseline Survey (Annex A)

For this survey in the form of a questionnaire, the author's permission was obtained by email.

This Information Literacy Baseline Survey model was planned, designed, developed, tested and implemented by the International Clearinghouse for Information Literacy and Lifelong Learning in Slovenia (CoIL-LL). It was utilized as a first actual or "live" test case using over two dozen Eastern, Southern and Central European countries in the European region (Horton, 2008).

The questionnaire consists of three sections/parts. Part I deals with questions addressed to government institutions. Part II deals with questions addressed to educational institutions. Part III deals with questions addressed to libraries.

The regular corporate employees were selected in order to add to the sample and provide more detailed information about the presence of political regulations about information literacy, and if these regulations have been successful.

Each section may be addressed separately to the intended groups, but the author preferred to receive answers from all the respondents and for all the questions, because employees in most of these institutions are subject to changed/changing positions due to transitions and political reforms, and there are many people that are working in a different environment regardless of their education…

Data are analyzed in Excel.

Research began in December 2011 and finished December 2012 to contact target groups and people, to gather the data and then to analyze them.

The survey targets the national level, but for the purpose of this research the questionnaires were distributed only in Tirana and Durrës (Central Albania).

A purposive sample was chosen for the particular characteristics of the respondents that are of interest, and which will best enable them to answer our research questions.

The researcher took special care and consideration in the selection process of institutions based on is research criteria. Institutions were selected based on many characteristics, including a few that had no direct relation to the topic, but whose input would be valuable in making the sample size more unbiased and representative of many layers in society.

Target groups of this sample were professors, teachers, librarians, government officials of different ministries, civil servants, Albanian employees of different non-governmental organizations, students, users of various libraries and others. We wanted to see, if the concept of Information Literacy is well known among the academic elite which are supposed to be the most important source of development and innovation in Albania. Therefore all the samples included subjects with university degrees, (as we'll see from the results, 70% of whom had advanced degrees including Masters and PhD).

Data collection

Respondents were asked to fill in the survey sections appropriate to their knowledge and expertise, but no strict rule was set that they must complete it all. They were informed that all individual responses will be anonymous and also advised to be frank and honest in their replies. It was possible to contact one of the government institutions, MITIK, only by post, and no answer was received. It was not easy to reach all the respondents that were working for the government. Some of the contact points at the main ministries never

returned the questionnaires although several attempts were made to meet them personally, by e-mail, mobile etc.

4. RESULTS-Presentation and SURVEY (Appendix A*:* Information Literacy Baseline Survey, please refer to the published paper)

4. DISCUSSIONS

The present research aims to provide sufficient evidence regarding the level of understanding of the IL concept in Albania, the level of development of practices, initiatives, trainings, programs in higher education and in the libraries, to identify needs, and to suggest practices and recommendations to the respective institutions and organizations.

The survey results show that the concept of Information Literacy is not well known among all, especially by the academic elite, which is supposed to be the most important source of development and innovation in Albania. Therefore, all the samples included subjects with university degrees, 70% of which had advanced degrees, including Masters and PhD.

Eighty-two percent of the respondents were not sure, if the term of "Information Literacy" is understood and ninety-eight percent of the respondents do not know, if an official policy does exist (65%) or not (33%).

Included in the selection were the ministries, public institutions, universities, schools and libraries. Unfortunately, the most important ministries directly linked and responsible for policy making in Information Literacy did not respond to the survey. The sources might be the negligence, and the absolute lack of knowledge on the part of the employees involved.

This confirms our first hypothesis that the level of understanding in Albania of IL not only by the general public but by a larger scope including: academic institutions, libraries, government or media is low. We assume that there are multiple reasons caused by the transition period Albania faced over the last 2 decades and the lack of information of or attention to this important human right.

Eighty-nine percent of the subjects are confident to indicate that they are not aware of any policy, nor any thought that such a policy has ever been considered. None of the subjects can identify what the policy is or the nature of the policy. This supports hypothesis number 2 that in Albania there are no official policies regarding IL, these terms are generally confused with information technology policies.

The research results support hypothesis 3 indicating that there are neither plans nor any immediate procedures which specify a time frame for the implementation of IL and what it will be based on. Based on the data, 89% of subjects report that any policy and procedure has yet to be adopted, 61% of

the respondents report not to be aware in which sectors this policy should be adopted, and 19% believe it will be in universities.

Fifty-two percent of the surveyees had an entirely different opinion concerning the responsible institution in charge of the official policies for IL.

The answer to this question proves our 4th hypothesis, that it is entirely unclear which of the institutions must initiate and supervise IL.

As above, our 5th hypotheses that "Knowledge resources in information literacy in universities are low or non-existent; furthermore, this phenomenon is due to a lack of understanding in the concept of information literacy" has been supported with the following results:

1. 91% of subjects report not to know or not to be sure, if such courses or trainings exist
2. 93% of subjects do not know the course's name, its level or the department linked to it
3. About 60% of subjects emphasize the lack of knowledge of the concept leading to the absence of IL at the academic level. Whereas 88% have no knowledge or are unsure, if such an issue will be addressed soon by the universities.

The same facts support our 8th hypothesis about a lack of Information Literacy curricula in Albanian Education Systems.

The challenge now is for higher education authorities to respond. Unfortunately for now, such dimensions are still invisible in educational strategies or policies, therefore inhibiting necessary and needed IL developments that would support the intended reforms (Spiranec and Pejova, 2010).

The results support the sixth hypothesis that libraries offer little or none information regarding IL. Answering the question, whether libraries or library associations in Albania offer IL education and training courses/workshops/seminars, 70% of the respondents did not know of any courses, while 30% reported knowing that the National Library has begun to include IL during master courses organized by this institution. Others, at Academic Libraries and the Library Association, are mostly linked with sporadic efforts to introduce Information Library, but not about regular courses, or because of the respondents' misunderstanding of the concept.

Regarding the implementation of IL, Horton (2008) reported the following for The Bangkok, Thailand Findings (December, 2005) on "IL Education and School Library Services": "The responses varied showing disparity across the region; where it is taught, IL is integrated into courses and/or taught as an orientation in the library; school libraries and teacher librarians seem to play a small role in teaching IL; in two out of seven countries IL is taught by teachers in libraries, and in five countries it is a part of extracurricular activities; lack of qualified teachers, librarians, computers,

and sufficient library collections were cited as the main factors preventing the teaching of IL".

The research results support all of our hypotheses. 60 of the respondents think that lack of interest, due to the concept not being understood, is the main obstacle to be overcome in improving IL. Twenty-five percent hold a lack of financial support to be the main obstacle, and 14% attribute problems to the fact that Information Literacy is misunderstood as equivalent to computer or media literacy. This is consistent with our 7th hypothesis about lack of interest. The results of this research are almost equal with the situation in other South-East European countries. These conclusions equal the results described by Spiranec and Pejova (2010) who found the following:

"Some countries with well-developed information and library infrastructures, and which have a higher level of understanding of the issues, have at least taken the first steps toward designing initiatives and program for IL development (for instance, Croatia, Slovenia and Turkey). These countries stand in contrast to countries like the Republic of Macedonia and Albania, which have a rather poor library and information infrastructure, and have no formal information and library education program at the university level".

The Information Literacy initiatives (Horton, 2008) must be undertaken in the context of the ongoing education policy formulation and reform. Advantage should be taken of the ongoing reforms to integrate IL into the educational system. As a goal for the ongoing reforms, specific targets and accomplishment milestones (benchmarks) should be set for integrating IL and Lifelong Learning into these foundational reforms as well.

As above, Research Results have verified that:

i) The level of understanding in Albania of IL not only by the general public but also by a larger scope including: academic institutions, libraries, government or media is low.
ii) As in Albania there is no official policy regarding IL, these terms are generally confused with information technology policies.
iii) There are no plans in the near future for the application of IL, nor which areas it will be applied to.
iv) There is no responsible institution who will initiate Information Literacy policies.
v) Knowledge resources on Information Literacy in universities are few or non-existent, furthermore this phenomenon is due to a lack of understanding in the concept of information literacy and lack of IL curricula at all levels of studies.
vi) Libraries offer little or no information regarding IL.
vii) Lack of interest in understanding IL and its importance is the main obstacle regarding IL in Albania.

The survey results confirmed that in Albania, there has not yet been a planned, prepared or implemented a strategy for Information Literacy at the national or local level. The level of understanding of IL is very low. There are no public awareness programs, there is no local research about Information Literacy, nor attempts to promote it; there are no trained information professionals and teachers in information literacy, library schools do not have it on their agenda, and information resource collections are very limited. ICT infrastructure is still underdeveloped, and there is no curriculum for training IL skills at all levels of studies. According to this researcher's experience, it is limited to one-hour library tours or misunderstood as being part of training in computer skills. Investment in information and library infrastructure is very limited. Less than 1% of the population has library cards. School libraries do not have any librarians. Usually one of the school teachers is serving in this capacity with very limited hours to maintain the library and keep it open. Commune libraries that existed twenty years ago are almost all "dissolved" or have changed function. Among those that are open, new materials are very limited or available only through donations.

We don't need to invent solutions for overcoming this big gap. For more than thirty years the road has been prepared through a variety of marvelous efforts and experiences all over the world. Standards, indicators and recommendations are set by different international organizations (UNESCO, IFLA, ALA, etc.). We simply need local people with interest in IL and experts to contribute through the identification of issues of concern, proposal of specific solutions, and through the development of creative strategies, as well as by encouraging librarians and teachers etc. to take the initiative in creating an IL learning environment. This will be the best investment in our communities and the results will be amazing in a short time.

Moreover, with the European Integration of Albania, and the corresponding steps we must take to be properly integrated, there is no time to lose.

5. CONCLUSION

Information Literacy in Albania will not happen by default. It must rapidly become a priority for the responsible authorities and will require cooperation among different ministries, libraries, universities and other institutions and professional organizations and associations. We must urgently prepare a "National Information Strategy and Vision" (Horton, 2008). In addition to making clear the IL concept and vision, we must consider the identification of problems and issues related to the application of IL international standards and the right path to resolve them.

The author of this research brought to the attention of the Albanian Library Association the need to publish in Albanian the book "Understanding Information Literacy: A Primer" (Horton, 2008), an easy-to-read, non-technical overview explaining what "Information Literacy" means, designed for busy public policy-makers, business executives, civil society administrators and practicing professionals. As Abdul Waheed Khan, Assistant Director-General for Communication and Information mentioned in the forward part of this publication, UNESCO asked Forest Woody Horton, an international information management expert, to prepare this Primer (Horton 2008).

The publication is available in the Albanian language, including a summary of recommendations from this publication that reflect our situation and the recommendations from this recent research, which will be given to the staff of the recently elected governmental ministries, public and private universities, libraries and librarians, interested professionals and organizations in the country that have the possibility to initiate and implement national strategies, plans, projects, trainings and other initiatives to foster and practice Information Literacy awareness campaigns, trainings etc.

Results show that Albania needs a better understanding of the Information Literacy concept, its benefits and requirements, and the integration of IL curricula, creating the right infrastructure in schools and libraries to support the new technologies and take the utmost care for further education and training for the librarians and teachers.

To follow the orientations of UNESCO, IFLA, the Prague Conference and other prestigious international organizations and to bring this National Strategic Plan of Action into reality, there is an immediate need for the creation of a National Advisory Committee with national experts and professionals from all the ministries, universities, libraries, agencies, institutions, civil society with assisted international expertise. They will design the time frame of short and long term projects and initiatives, the required infrastructure, financial assistance and other implications.

Wilkinson & Bruch, IFLA 2012 suggested using an external adaptation or internal integration, previously identified at our institution to ask ourselves which strategic change might work best to resolve the issue.

Until further steps are undertaken, consulted and decided upon to follow, we may use "meta-tool", developed by the IFLA section on IL and other universities, libraries, associations etc. Incorporating an Information Literacy curriculum into their system can help schools attract more students and graduate more-informed students who are better prepared to cope with 21st century challenges (Horton, 2008).

Albanian libraries, librarians, and the Library Association need to take a leadership role in creating a lobby and in building and supporting IL

initiatives, strategies, and collaboration among school and academic libraries. They need to foster a dialog among ministries and local government authorities responsible for libraries and other NGOs interested in the field of raising IL awareness, supporting IL infrastructure and training.

Public and school libraries need highly qualified librarians in the Library Science. School and commune libraries are in urgent need for special attention. Not only regarding space, but also infrastructure, including books, audio-visual and e-resources, and most importantly, full-time qualified librarians. As per the author's knowledge and the national survey of 2012, mentioned in Literature Review, there have been years without any training for school librarians while their actual job position was only two hours per week. We have to follow the example of other European countries that have full-time librarians with Master Studies in Library Science employed in school libraries.

The first group of 15 selected Albanian librarians is completing successfully the Second Level Bologna Regional Part Time Master Studies at the University of Ljubljana, supported financially by the Slovenian Government. This group of people will be a valuable asset to the country and needs to be actively involved in the process.

The Ministry of Tourism, Cultural Affairs, Youth and Sports with its National Council of Libraries based on the Law on Libraries in the Republic of Albania, No.8576, Item of the Law14 (Year 2000) and Law No.9217 (Year 2004) for some amendments on the Law 8576, has to take the leadership in its role of fostering inter-institutional collaboration regarding this important IL issue, draft and follow the National Strategy and Action Plan and prepare Information Literacy legal support.

The Albanian Ministry of Education must revise the previous experiences and create a new Department of Library Science according to international standards, expertise and procedures. That will soon fill the gap created by the transition and tradition in Albania.

The practices in IL context, possibilities and results around the world are amazing. The role of all libraries is crucial in this process. Each of the librarians, with their love, patience and devotion are an "added value" to this process and should continue spreading their awareness and training efforts.

To incorporate IL training with teaching other academic skills, (Howard, 2012) suggests " Consultations with schools and faculties…to identify existing good practices, gaps and areas for future development…identify some key projects in different program areas".

Talented youth may be consulted about Information Literacy and its impact in all fields of life and to collaborate with experts in Media, Information Literacy and Science Library for creating proper applications and

online or mobile tutorials in the Albanian language and continue further research in the field.

Global developments are offering a mosaic of solutions and choices. Albania must immediately develop a national “frame of reference” for Information Literacy that will put IL and Life-long Learning on the right track with progress towards well-defined objectives and roles for government stakeholders, libraries, educational institutions, and other segments of society, as well as legal support.

There is a strong, qualified community of about 350 librarians around the country. They work in public libraries, in state or private schools, universities, organizations, etc. Yet, most people do not know what IL is. Until we have a common understanding of IL and its importance, until we build strong academic and social relations between the librarians, teachers and students, until we are trained properly, until the school libraries have qualified librarians and a suitable infrastructure, until we have national and local strategies, until the “top-down approach” is in motion, until we have the IL legal support, we have to be creative, trying something new and looking for the best experience around.

All men have been created to carry forward an ever-advancing civilization. The author hopes that this paper will foster the IL in Albania.

ACKNOWLEDGMENT

I am grateful to the Slovenian Government, that through IZUM and the Department of Library and Information Science and Book Studies at the Faculty of Arts, University of Ljubljana, the Albanian Library Community had the chance that for the first time, a group of selected students/librarians were able to complete their advanced regional part-time master studies in Library Science, to stay updated with the developments in the field and apply their knowledge at the workplace as well as nation wide.

I wish to address special thanks to Mr. Tomaž Seljak, former director of IZUM, for taking care to follow our academic advancement, for accompanying us to build bridges of networks with Slovenian, regional, and international institutions and for supporting Albanian libraries, academics and students with recent important information, useful for reaching personal, professional and national goals.

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Albanian libraries at international library events. My gratitude extends to all the Academic Staff of Ljubljana University and their collaborators, and especially to the Department of Library and Information Science and Book Studies, as well as the Head of this Department, Prof. dr Primoz Juznic, who accompanied us with care and patience during the study years and many others special souls.

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APPENDIX A: (link below) INFORMATION LITERACY BASELINE SURVEY

https://www.morebooks.de/store/es/book/information-literacy-in-albania:-the-role-of-libraries/isbn/978-3-659-76756-2

DA VINCI'S VITRUVIAN MAN, THE PERCEIVABLE, THE UNPERCEIVABLE AND THE PHANTOM SENSATION.

Apostol VASO
Trauma University Hospital, Tirana, Albania

***Keywords*:** da Vinci, geometry, perception, sensation, the perceivable, the unperceivable, total body water, inter-cellular fluid, phantom sensation, laminar flow.

I. The geometrical logic

The geometrical solution of Vitruvian Man's sketch by Leonardo da Vinci confirms that it is the graphical presentation in plan of the undividable (atom). This represents the "cuneiform script" formula of the relationship between a sphere and its correspondent cube with equal volume. The graphical presentation is the only formula, because the mathematical calculation for the water volume in a cube ($V=a^3$) does not correspond exactly to the mathematical calculation of the same volume of water in its corresponding sphere ($V= 4/3\pi r^3$), which means we cannot use the mathematical calculation for the "true exactness".

Based on da Vinci's quote "Every flexible and liquid element has of necessity its spherical surface"[1] we can say that the above formulation expresses the mathematical unperceivable tendency of any matter to make it to its spherical surface and this tendency itself results to be the reason of its movement. As Putnam states in his work: "In ancient Greek, 'hydor' was not only the substance we drink, but was also the name of an element, and as an element, it was virtually a universal principle of liquidity"[2] and "it may be objected that the Greeks (who of course used the word "hydor" which cognate to our present "water")" not because "did not have the concept of physical law,"[3] but because they operate beyond the physics, and the method needs to be based on logic or geometry, not in empiricism.

The concept of the ideal sphere is considered to have no need for the physical laws, and every deviation from it results in movement. In this

context, we can also understand that the ancient Greek phrase “Ariston men Ydor” does not mean, “water the best”[4] but expresses the idea that the “perfect”, or the circle, is the graphical presentation, on the surface plane, of the ideal sphere. Therefore, there is no perfection without water, which will be the fundamental theoretical argument in our hypothesis.

According to this point of view, the necessity of the matter (body) to its spherical surface results in the ratio between the tendency of our total body water (fluid) to the sphere, and the elasticity of the body tissues, which can be demonstrated by two variations of squaring the circle, one of them as used by da Vinci in the creation of his Vitruvian Man sketch.

II. The laminar water flow - as a present key element in the metamorphosis (modeling) of the squaring circle process.

The sketch with square and circle constructed by da Vinci (fig.1) presents the frontal plan surface of sphere and cube. Meanwhile the sketch known as “squaring the circle” (fig 2) expresses the horizontal plan surface of the cube and the sphere as mentioned above. Consequently, as we present the plan surface of the sphere corresponding to the frontal and horizontal plan, the circles in fig. 1 and 2 have the same radius.

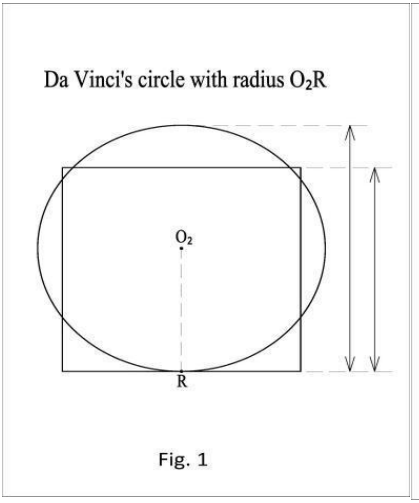

Fig. 1

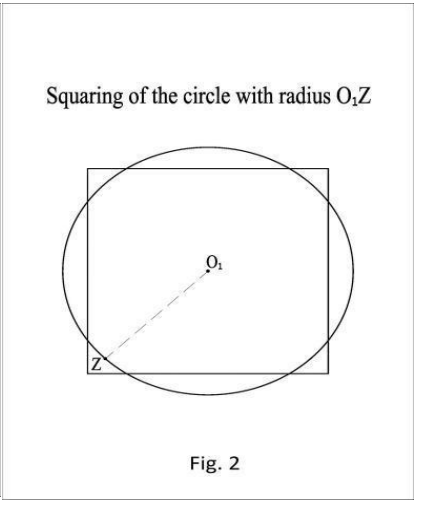

Fig. 2

Until now, squaring the circle is considered "to attempt the impossible”[5], but seen in the perspective of presentation of the sphere (ydor) and the corresponding cube in a plan, the construction of the squaring of the circle is accomplished very easily by da Vinci with compass and ruler. From this point of view, we can understand Aristotle’s conclusion “But as usually framed, the terms of definitions are merely like conclusions. Thus, for example, let us ask:

- what is squaring? The answer would be that squaring is the construction of a rectangular equilateral figure to another figure with unequal sides. Such a definition is merely like the statement of a conclusion, on the other hand, to say that squaring is the discovery of a mean proportion it is to state the cause which explains the results".[6]

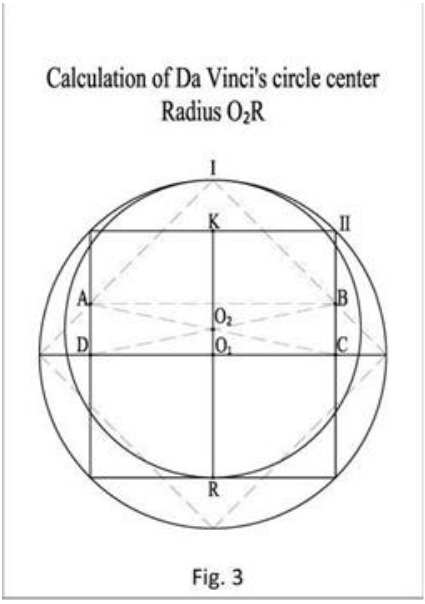

Fig. 3

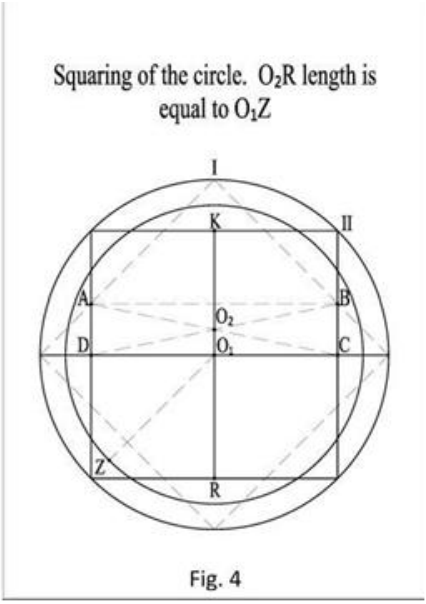

Fig. 4

Fig. 3 and 4 represent two squares inscribed to the same circle, with the center O1 against each other in a 45° angle. The circle with the center at O1, which inscribes these two squares, graphically expresses the perceivable rotation of the cube.

Fig. 3 represents the way of finding not only the center O2 of the other circle constructed by Da Vinci in the Vitruvian Man Sketch, but also the frontal plan surface of the necessity of the cube to the spherical surface (ydor). Both sketches in Fig.3 and 4 respectively present the ratio between the perceivable and the unperceivable circle (the tendency to ydor), whereas center O2 is the mean proportion proposed by Aristotle, constituting the center of the tendency.

The center O2 of this circle is the cross point of the diagonals of the rectangular figure ABCD shaped by the crossing of the side length of the two squares in the points A, B, C and D, where the diagonal of the square 1 divides in half the square 2. Meanwhile, if we move the tip of the compass from the center O2 to O1, maintaining the same angle of the compass, we

accomplish the squaring of the circle. This center also coincides with the center of the sphere of our total body water.

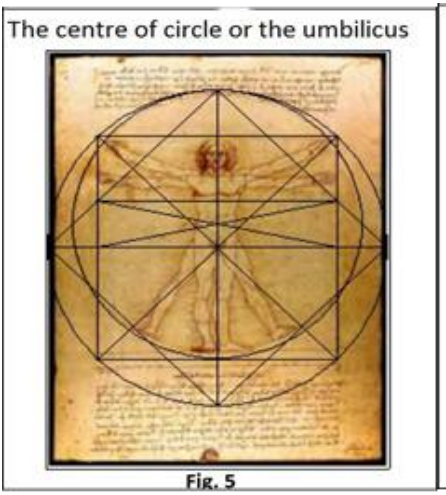

Fig. 5

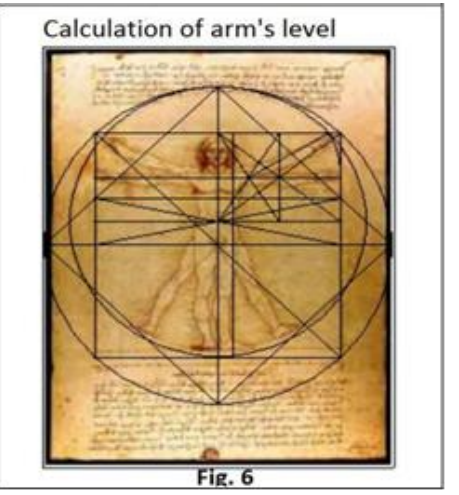

Fig. 6

Fig. 5 and 6 also confirm the exactness of this sketch with AutoCAD software.

Fig 6 represents the way of finding the height of the arms in the Vitruvian Man Sketch created by Da Vinci, but at the same time the laminar movement of total body water during the process of metamorphosis of the hard matter of our body, from sphere to cube, or vice versa, when it tends to become perceivable or perfect.

Accomplishing the challenge of squaring the circle, which is considered in the course of centuries "attempting the impossible," confirms the exactness of da Vinci's Vitruvian Man Sketch, where our body (both the total body water and the hard matter of the body) undergoes the same process as the metamorphosis of the sphere into a cube. This proportional transformation in our body coincides with the process of modeling. As we can see in Figs 5, 6, 7 and 8, every part of our body coincides with the crossing of the diagonals, meaning infinite exactness or a fractal network. This geometrical (graphical) infinite exactness (fractal network) coincides with the finest tissue structure and its corresponding laminar flow of our total body water.

Calculation of the height of the arms

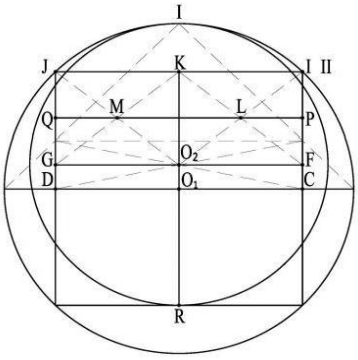

Fig. 7

Calculation of Da Vinci's circle center
Radius O_2R

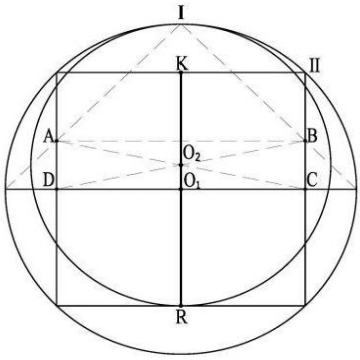

Fig. 8

The point O2, Fig. 8, is the cross point of the diagonals AC and BD belonging to the rectangular figure ABCD, which corresponds with the umbilicus of Vitruvian Man. The height of the arms of the Vitruvian Man in the Sketch of the genius (fig 4 and 7) derives from the segment connecting the points M and L, which are respectively the crossing points of the diagonals GK and O2J of the rectangular figure O2GJK, and also, of the rectangular figure O2FIK with the diagonals O2I and FK, where one of the angles of these two rectangular figures is found to be the umbilicus of the Vitruvian Man.

The absolute exactness, referring to the calculation of the umbilicus, height of the arms, knees and the articulations of the upper limbs, shows that our body is an exact formula of a laminar fractal network and completely justifies Plato's quote "And consider the matter in that precise way of speaking" Then medicine, "said I, "does not consider the advantage of medicine but of the body".[7]

Sketch 1. Copyright. The Morgan Library & Museum / Art Resource, NY; ART126979.

III. Better understanding of the modeling process in nature as an unperceivable event (absence of biochemistry).

Referring to the coincidence between the umbilicus and the cross point of the diagonals, which results into a unique center O2 of the circled square, and to the Euclid's 1st definition "A point is that which has no part"[8] we can say that mathematically the human body is sensitive even to nothingness. This happens because the ideal sphere needs an ideal proportion, with the hard matter of our body (sketch.1). In this meaning, when Euclid defined the "point", he complemented Aristotle's statement "that there is a thing which cannot be measured, even by the smallest unit."[9] This universal statement confirms that the point is undividable, and it can't be measured even by the smallest unit of time or space.

Inspired by the above quotes, we should search in the structures many times smaller than the neurotransmitters and receptors, even smaller than the chemical particles. From this point of view, we can say that the point is the fundamental unit, and the combination of those units is our attribution in modeling the dimensions without time. Within us, this results in the modeling of the straight line, plan surface, ideal sphere and ideal cube. This process without matter brings us to the conclusion that the metamorphosis of the cube to the sphere, or vice-verse, is our attribution of perception, because this

process of changing the form (from sphere to cube) happens without time, only in space with laminar movement.

Therefore, the sensation results in an unperceivable event which happens in the sequence between two smallest units of time, because the attribution of the total body water (the ideal sphere) is to be sensitive even to the smallest particle of matter. Hence, the sensation is the attribution of the total body water, but this is the starting point or the first principle of our perception too. Since the ideal sphere feels the nothingness, we can't operate with empiricism on it , hence the only way is to speak about it, with the logic or the Euclidean geometry. The entirety of the proportional mathematical rhythm between the infinite square and circle fig.9. is metamorphosed into us as the process of modeling the feature only in space (from sphere to cube or cube to sphere or the spiral), resulting in "our attribute" of perceiving the cyclic reality.

IV. The sensation, the perception and the Memory concept.

Every deviation (dis-rhythm) from this mathematical proportional rhythm[10] between these events provides us with the perception of the three dimensional and time reality, which moves and changes permanently. This deviation is the starting point which also coincides with memory. Memory is the best condition in life (health), the point of reference (comparison) when the human being is complaining.

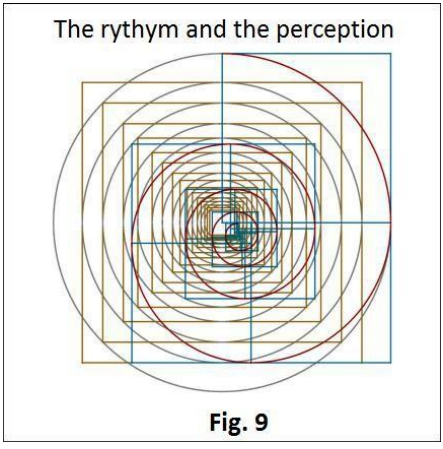

Fig. 9

Fig.9 represents the mathematical rhythmic proportioned events - the "first principle of time", or the perspective. Every deviation (dis-rhythm) from this basic rhythm is the presence of another ideal figure between the rhythm square-circle (time reality with perception).

The figure also clearly shows the proportional rhythm from the circle to the square. The proportional rhythm is also the perspective without any change, and this shows our attribution to perceive the time. The spiral (Fig.9) is the metamorphosis (the modeling process) of the projection of the geometrical rhythm. This is our attribution of the perceivable events, which is the result of this ratio in a different shape in three dimensions. This coincides exactly with the quote from Aristotle: "For the ratio is the essence, while the number is the matter"[11]. Every disproportion in the rhythm will result in a three-dimensional spiral with time and feature.

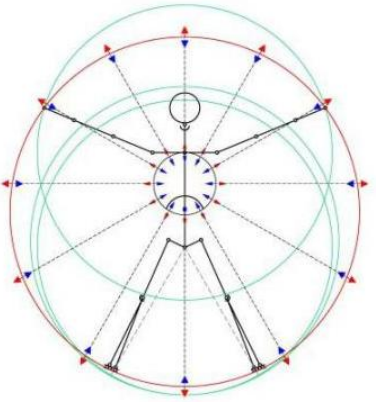

Fig.10

The geometrical calculation in Fig.6, results in a fractal network which gives us the possibility to design the graphical presentation of the finest structures in our body, even smaller than the neural structure[12] or the interstitium[13] in their ideal form. Based on this we can design the constructing of Vitruvan Man in a different way from the original one, which is a novel approach of the respiratory mechanisms. Constructing the thoracic cage with the circle, which express the tendency of sphere, with the same proportion as the original, we can calculate geometrically the relationship of the thoracic cage with the ideal form of the human body.

Meantime the lines in Fig. 10 show the direction of the muscle forces in the inspiratory and expiratory act. This is also the principle of the relationship between the ideal respiratory rhythm and the ideal elasticity of the body structure which results in a pump moving the inter-cellular fluid in laminar flow. Every deviation from this ratio, even in the smallest unit of time, results in dis-rhythm, and the laminar inter-cellular flow will change in the chaotic movement or vortex. The three-dimensional structure in time will suffer

proportionally the structural deformation in all its entirety from every sequence deviation from the ideal rhythm. Therefore, the presence of fluid has important implications for tissue function and pathologies in all the organs, which are subject to these cycles of compression and distension, whether relatively constant or intermittent.[14]

V. The mechanism of phantom sensation

The maladaptive structural plasticity in neural circuits[15] occurs not only in pain conditions but much earlier, even much earlier than we can perceive.

Fig. 11. Frontal view of functional scoliosis in an amputee patient.

Fig. 11 represents the images of CT examination conducted in a patient that complained from the phantom limb pain after the amputation, "Table 1. (Patient No. 5R hip disarticulation, trauma, 2 yPLP (severe), npPLS (knee to foot), Tinel?PLP)".[16]In the SCOUT severe scoliosis of the spine is observed, which corresponds with the side of the amputation. The equilateral angle of the 12-th rib projected to the spine is narrower, compared with that of the controversial one, and suggests for local inserted muscular contractions. That is the main reason of the evident asymmetry of the hemithorax (shape) and the asyntonisation (dis-rhythm) of the diaphragm during the respiratory process. We conclude that gray matter changes in limb amputation[17], it is also not a separated finding from the proportional fractal (fig. 6), but it is related to the entirety of the body structure without excluding the respiratory rhythm.

Fig. 12

Fig. 13

The setting of the nerves and the diaphragm gives to the sketch of Vitruvian Man the attribute of the ideal ratio of inspiration-expiration or homeostasis, which is carried out by a diaphragm ideally proportionate and harmonious in movement and supported by an ideal innervation. (Fig 12)

The realization of concentric circles (laminar flow) creates the idea of the fluid that takes its origin from the circle's center, hence the umbilicus. Clearly seen from this standpoint, the pneumatic movements of the thoracic cage, during the respiration act, realize concentric circles. This is the ideal perspective of the flow, which is without obstacle. The fluid, which should be influenced in this way in our body, coincides with the interstitial water (fluid), which according to this sketch is propelled by a pump that has the umbilicus as its center during the respiratory act.

In amputation case, the perspective will change, and the circular ideal wave of inter-cellular fluid will become a swirl, because of the stamp (obstacle) and the center deviation. If you try to calculate this swirl in the obstacle, it will result the ratio between the dis-rhythmic inspiration-expiration alternations and the form and the level of the stamp. The form of the swirl, which results from this calculation is the phantom sensation that patient refers, (Fig 13). This swirl will influence in the smallest unit of time all over the total body water and also in the three-dimensional structure of the hard matter of our body, which has been adapted at the same time from the amputation.

The graphical presentation, which results from the above calculation, represents the phantom sensation that the patient refers. Similarly to Plato's quote about the advantage of the body[18], it can be speculated that the current scientific researches in neuroscience on interpreting the perceivable

(amputation) and unperceived conditions (phantom sensation)[19] experienced by the human body, are fragmental and not holistic, far away from a deductive and final solution. The above hypothesis aims to a novel approach, not only on phantom pain sensation, but it expands on a better understanding of the multiple role of the total body water in our sensation and the inter-cellular fluid in our perception. And, in the realms of the treatment methodologies and technical supports, the hypothesis aims to offer new and innovative alternatives, focusing on patient, clinical practice and basic bio-medical research.

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IN MEMORIAM: COSIMO LACIRIGNOLA

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Cosimo Lacirignola was agricultural economist and graduate of the University of Bologna, Italy and the Secretary General of the CIHEAM -International Centre for Advanced Mediterranean Agronomic Studies for five years.

He was appointed the Director of the Mediterranean Agronomic Institute of Bari, Italy, one of the four Institutes of the CIHEAM in 1987, a position he held up to 2016.

He was keen on promoting welfare and peace in the Mediterranean countries through scientific collaboration. As a scientist he was a staunch defender of common knowledge among the young generation of the region in agriculture, food and fishery. At the CIHEAM, he trained and supervised researches and cooperation projects in the Mediterranean and other regions of the world, Albania and Kosovo in particular, by setting up a common vision, principles and objectives, recently under the CIHEAM Action Plan 2025 for the Mediterranean (*CAPMED*2025) following a collaborative approach. For its

implementation, the CIHEAM works in close collaboration with the Food and Agriculture Organization (FAO) of the United Nations and the European Commission and the European Union for the Mediterranean region.

Cosimo Lacirignola has also acted as advisor for international relations to the Ministers of Agriculture of three different Italian governments. He was also head of the International Relations Office of the Italian Ministry of Agricultural, Food and Forestry Policies (MIPAAF) from 1998 to 2000, then from 2002 to 2006. He was the president of the Fiera del Levante in Bari from 2006 to 2011. Cosimo Lacirignola is the author of numerous articles and several books on agricultural, water and EuroMediterranean issues. He is also *Commander* of the Italian Republic, Commander of the National Order of the Cedar of the Republic of Lebanon and *Laurea Honoris Causa* of the Agricultural University of Tirana in Albania.