B. ACTIVITIES RELATED TO DATA SYNTESIS

At this stage we focused on the following objective:

2. ANALYSIS AND CRITICAL DISCUSSION OF THE CURRENT MODELS ASSOCIATED TO GEODYNAMIC EVOLUTION OF THE EAST CARPATHIANS IN CONNEXION WITH MIOCENE-QUATERNARY MAGMATIC ACTIVITY (1).

2.1. GEODYNAMIC MODELS FOR THE EAST CARPATHIANS (1)

Geodynamic reconstructions in the Carpathian-Pannonian Region (CPR) are the result of manifold geological and geophysical approach. The progress in the geodynamic reconstructions is reflected in the successive models realized up to now. The initial models were generated by using mainly geological information, whereas the recent ones includes increased petrological and geophysical data. The first models discussed geosynclinal theory. An important step in the knowledge was the introduction of the global theory of plate tectonic developed at the beginning of the 70th (ex. Dickinson, 1971). According to this new theory, the early geodynamic models for the CPR adopted the model of circum-Pacific areas, so that all the mountain areas at the border of European Plate were interpreted as a result of the collision between an “island arc” and the European continent. “Island arc” were defined by their characteristic structural elements: (1) oceanic plate; (2) through; (3) folded basement; (4) calc-alkaline magmatic arc; (5) a backarc basin. The items (3), (4) and (5) have been considered in some models characteristic for CPR, at that time assimilated as an arc-type, or even “island arc” type (ex. Bleahu et al., 1973; Rădulescu, Sândulescu, 1973; Boccaletti et al., 1973) (Fig. 10).
The following research studies evolved following two schemes: tectonic reconstruction (1) and reconstruction of magmatic processes (2) in this way enhancing the previous simplistic models with complex models that highlight the special peculiarities of the Alpine-Carpathian-Hymalayan belt, as different from the circumpacific one (e.g. Prelevic, Seghedi, 2013).

(1) The geotectonic reconstructions proved that the basement of the Intra-Carpathian area is composed of several continental blocks (terranes), recognized in the literature as ALCAPA, Tisia (Tisza) and Dacia (e.g., Balla, 1984, Csontos et al., 1992; Schmid et al., 2008). ALCAPA block is situated in the northern part of Pannonian Basin, since Tisia and Dacia are successively developed in the southern part of the Pannonian Basin, including Apuseni Mts and Transylvania Basin. ALCAPA block is separated by the Tisia block by a major tectonic
dijunction known as Mid- Hungarian Line, active probably since Cretaceous times and a place of numerous tectonic deformations (e.g., Csontos et al., 1992; 2002).

Tisia and Dacia blocks were characterized by a different geologic history during the Mesozoic times, as reflected also by the paleomagnetic data (Pătraşcu et al., 1994). The welded crustal Tisia-Dacia entity is a result of Early-Middle Cretaceous collision, as suggested by the crustal thickening and tectonic nappe generation in Apuseni Mts. (e.g., Balintoni 1997; Dallmeyer et al., 1999), South and East Carpathians (e.g., Sândulescu, 1984, Berza et al., 1994). Geological data suggests that Alcapa and Tisia blocks were derived from the northern margin of Adria (=Apulia) block (e.g., Sândulescu, 1994; Schmidt et al., 2008). Geodynamic evolution of these blocks during the Neogene implied translation and rotation of the mentioned blocks (e.g., Csontos, 1995; Fodor et al., 1999; Csontos et al., 2002).

Recent tectonic reconstruction of CPR (e.g., Csontos, 1995; Fodor et al., 1999; Huismans et al., 2001; Ustaszewski et al., 2008) suggests that Tisia was translated toward the east during Early-Middle Miocene, along the Alcapa block (Fig. 11).

Such complex tectonic processes generated an impressive active force of movement of the tectonic blocks that implied rotation, collision and accretion suggesting the probable implication of the subduction accompanied by rotation of the lithospheric blocks presently attached to the European Plate (e.g., Royden, 1988; Sândulescu, 1988; Royden & Burchfiel, 1989; Csontos et al., 1992; Csontos, 1995). Paleomagnetic data prove a clockwise rotation of ~20° during Eocene- EarlyMiocene times (Pătraşcu et al., 1994; Panaiotu, 1998), period when ALCAPA suffered ~30° counterclockwise rotation processes (Márton, Márton, 1996).
Fig. 11. - Restoration of tectonic units in the Alps, Carpathians and Dinarides domain for the Early Miocene. Colours and patterns of tectonic units after Ustaszewski et al. (2008)

Starting to Middle Miocene Tisia and Dacia blocks have been implicated in rapid clockwise rotation (~60°). These rotations started at ~14 Ma, diminished at 13 Ma up to 28° and stopped at ~12 Ma (Panaiotu, 1998, 1999). Between 14-12 Ma, only the north-eastern part of ALCAPA was rotated, as counter-clockwise between 50°-20° (Panaiotu, 1998, Márton et al., 2000). Important clockwise rotation of Tisia (along Dacia) (Apuseni Mts.) generated during Badenian – Early Pannonian times, at the upper crustal levels normal faulting perpendicular on the rotation axis (e.g., Csontos et al., 2002). These faulting was responsible for a series of basin generation of core-complex type toward NW-SE direction, visible along the western margin of the Apuseni Mts. (e.g., Royden, 1988; Sândulescu, 1988; Balintoni, Vlad, 1998). Similar graben type basins were detected in the adjacent Pannonian Basin (e.g., Balla, 1984, 1987; Csontos, Nagymarosy, 1998; Csontos et al., 2002). This type of extensional basins is synchronous with major rotation and coincides with sedimentation and magmatic processes strating with Early Badenian (e.g., Balintoni, Vlad, 1998; Roşu et al., 2004; Seghedi et al., 1998, 2004). A schematic geodynamic evolution is given in the in Fig. 12, after Csontos et al. (2002; figura 12c) and Seghedi et al. (2004; figura 2b). Upper figure (Csontos et al., 2002) presents the geodynamic situation at the end of major rotations (Pannonian times). Lower
figure after Seghedi et al., (2004) sugest that the Apuseni Mts. magmatism, as part of Tisia, is in direct connection with the major clockwise rotations between 15.5 - 11 Ma, when the core-complex type extension was associated with graben type basins. In this time interval contemporaneous calc-alkaline magmatic activity developed in the front of Alcapa and Tisia blocks (Pécskay et al., 1995a,b; 2006), in direct connection with similar type of core complex lithospheric extension as for Tisia (e.g. Nemčok et al., 1998; Seghedi et al., 1998, 2001, 2004; Seghedi, Downes, 2011). The collision of Tisia block during Upper Miocene (~11 Ma), was considered as a result of the end of subduction retreat with implication of East European Platform megablock (e.g., Csontos, 1995; Maţenco, 1997; Zweigel, 1997).

Fig. 12 – Simplified sketches of geodynamic evolution of CPR during Middle-Upper Miocene. This figure reproduces the Fig. 12c from Csontos et al. (2002), suggesting the geodynamic situation resulted during main rotation and translation toward the east (corresponding to Pannonian time). It can be observed the differential rotation processes corresponding to the central and eastern part of Tisia, and also the graben basin opening in the western Apuseni Mts. The lower figure reproduce figure 2b in Seghedi et al. (2004), showing the distribution of the magmatism inside Tisia block (Apuseni Mts.) as being in close relationship with peak rotation period between 15.5 - 11 Ma, concomitant with graben generation. In the same time interval the figure is showing the presence of a contemporaneous calc-alkaline magmatism in the front of Alcapa and Tisia blocks.
Starting to Upper Miocene up to the present times the stress indicators suggests the prevalence of a compresive stress in the southernmost part of the Transylvania basin and its margins toward E-W and NW-SE, followed by an important isostatic uplift (e.g. Huismans et al., 2001; Ciulavu et al., 2002; Sanders et al., 2002).

Between the mentioned internal blocks and the European platform the Carpathian nappes were compressed with ca. 160-260 km (e.g. Morley, 1996; Behrmann et al., 2000; Maţenco et al., 2007; Ustaszewski et al., 2008). The contraction processes finished at ca. 11 Ma, but this episode is controversial, since assume subduction processes of a lithospheric material not yet specified.

(b) The studies generated after 1995 concerning the age of the magmatic rocks deny their generation as a result of a direct subduction process, as suggested in the previous studies, taking into account the supposition that the calc-alkaline magmas should be exclusively related with direct subduction processes. In the East Carpathians the volcanism postpone the generation of nappe tectonic units and it is subsequent in Upper miocen-Quaternary times, and in consequence is post-collisional (Mason et al., 1996, 1998, Seghedi et al., 2011) as generated during contemporaneous extension tectonic processes (Fielitz, Seghedi, 2005). Călimani-Gurghiu-Harghita (CGH) chain represents an important volume of calc-alkaline products joined in its southern part by small volume basaltic Na-alkaline and potassic alkaline associations (Szakács, Seghedi, 1995; Seghedi et al., 2004, 2011; Seghedi, Downes, 2011; Lexa et al., 2010). This pattern suggests a continuous N-S rejuvenation in the 11Ma-recent interval (ex. Pécskay et al., 2006). In fact all the magmatic occurrences along the East Carpathians including Oaş-Gutâi volcanic areas, “subvulcanic zone” area (Gröger et al., 2008; Pécskay et al, 2009) and CGH volcanic chain, strongly evidenced in topography, were generated close to the collision zone of the Carpathians as a result of post-collisional complex tectonic deformations. Such processees facilitated a development of a complex fracture system, extremely active during the magma generation at the surface (Fielitz, Seghedi, 2005). At that time the contemporaneous magmas were acting as a lubricant for tectonic processes (Seghedi, Downes, 2011).

This is a clear demonstration that calc-alkaline magmas were generated not as a direct product of subduction processes, but as a result of adiabatic decompression processes and
lithospheric partial melting during post-collision stage. To generate such kind of magmas it was necessary that the lithospheric mantle to conserve former subduction components (fluids, sediments) (e.g. Seghedi et al., 2004). The presence of a high thermal flux superimposed to CGH volcanic area (e.g., Tari et al, 1999; Demetrescu et al., 2001) is suggestive for acceptance of asthenosphere upwelling, that could be explained by oblique collision and progressive breakoff from N-S, appropriate volcanic activity migration in time and space in the same direction (Mason et al. 1998; Seghedi et al., 1998; Wortel, Spakman, 2000). The volcanic areas of South Harghita and Persani Mts. is the most controversial since of its unusual tectonic setting that produced up to now a numerous geodynamic models (e.g. Cloething et al., 2006; Ismail-Zadeh et al., 2012 şi referinţele incluse) and of its very complex magmatic rock petrology (e.g. Downes et al., 1995; Seghedi et al, 2011) that imply the connexion with Vrancea seismic area.

C. FIELDWORK ACTIVITIES

This material speaks of the third objective of the project:

3. THE IDENTIFICATION AND DESCRIPTION OF THE MAIN TECTONIC ALIGNMENTS THAT WERE ASSOCIATED WITH MAGMATIC ACTIVITY, BASED ON GEOLOGICAL AND GEOPHYSICAL DATA - FIELDWORK

3.1. GEOLOGICAL STUDIES IN THE PERŞANI MOUNTAINS

Fieldwork was performed in the Perşani Mountains in order to identify the volcanic structures, to constrain the processes that influenced the types of eruption and in order to identify the tectonic elements which favored the transportation and extrusion of magmas. The working methodology was based on detailed mapping of the volcanic area and on describing the structural, textural and compositional features of the magmatic deposits, and the spatial relation between them. A first result was the discovery of 6 new volcanic structures that were previously unknown. They consist in 6 craters associated with phreatomagmatic deposits (tuff rings and maars), 4 lava flow fields and 3 strombolian scoria cones. A part of the new cartographic image is shown in figure 13, as an interpretative tectonic and volcanologic sketch.