New paleomagnetic results from the South Harghita volcanic area (Romania)

Madalina Vişan (Institute of Geodynamics "Sabba Stefănescu"), Teodora Merezeanu, Andrei Panaiotu, Cristian Panaiotu (University of Bucharest)

INTRODUCTION

Based on the spatial distribution, temporal evolution and geochemical features (Seghedi et al., 2004), Neogene magmatism in the Carpathian-Pannonian area can be divided into more segments, which include the South-Eastern segment from Calimani (North) to the Northern part of the South Harghita Mountains (Seghedi et al., 2004). This part is characterized by the presence of large amounts of calc-alkaline rocks formed between 10 and 3.5Ma. After this period, the activity continued south-eastwards into the South Harghita area, in which activity started (ca.3 - 0.03Ma), with contemporaneous eruption of calc-alcaline, shoshonitic and alkali basaltic. Previous paleomagnetic results from the South-East segment are from 4-6 Ma old volcanic rocks (Pătrascu, 1976). In the South Harghita Mountains only several sites are reported: 3 sites in the Northern part of the area (Pătrascu, 1976) and two sites in the Southern part (Michailova et al., 1983). The present paleomagnetic study is focussed on the last 5 Ma of volcanic activity in the South Harghita Mountains.

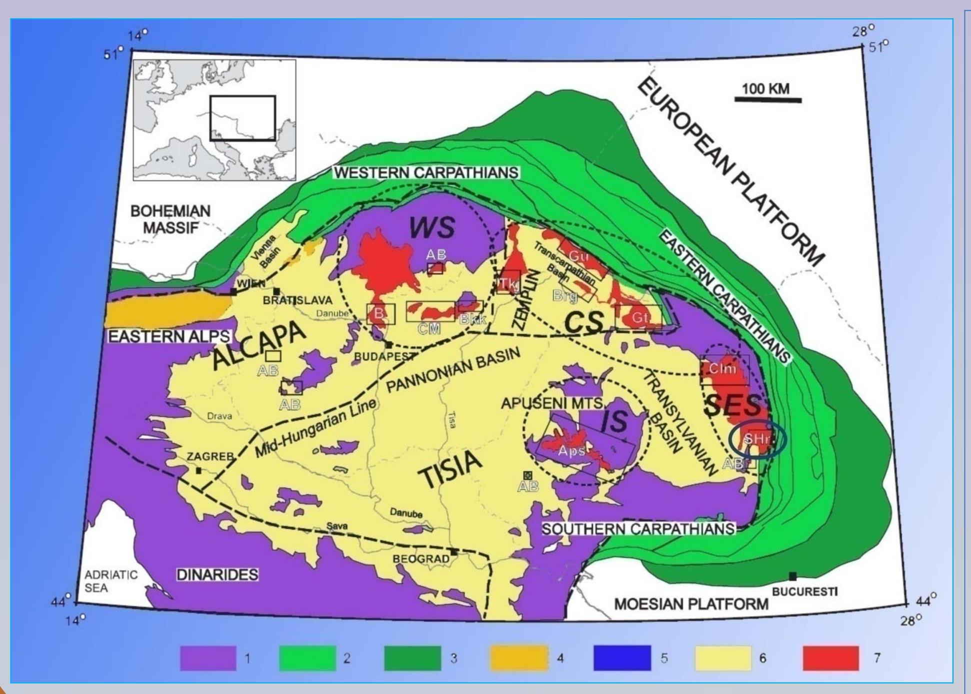

Fig 1: Geological sketch map of Carpathian–Pannonian region showing spatial distribution of the four defined segments (WS—Western segment; CS—Central segment; SES—Southeast segment; IS—Interior segment) and location of the calc-alkaline volcanic areas (B—Börzsöny, CM—Cserhát-Mátra; Bkk—Bükk foreland; Tkj—Tokaj; Gu—Gutinski; Brg—Beregovo; Gt—Gutâi; Clm—Calimani; SHr—South Harghita; Aps—Apuseni). Alkalic basaltic areas (AB) and Intracarpathian block boundaries (ALCAPA, Zemplin, TISIA) are also shown; Legend: 1: Inner Alpine Carpathian Mountain belt and Dinarides; 2: Alpine–Carpathian Flysch belt; 3: Carpathian Molasse belt; 4: Calcareous Alps; 5: Pieniny Klippen belt; 6: Neogene–Quaternary sedimentary deposits; 7: Outcropping calc-alkaline volcanic rocks. (Modified after Seghedi, 2004). Sampling area is marked by a blue ellipse.

SAMPLING AND METHODS

The oriented samples were collected from 68 sites (**Fig. 2**) distributed in various volcanic rocks from the South Harghita Mountains (andesites, basaltic andesites, dacites and shoshonites). They were obtained using a portable drill and oriented using both a magnetic and solar compass. Up to three standard 25x22mm cylinder specimens resulted from each core.

• **Magnetic mineralogy** was identified using the variation of magnetic susceptibility (MS) with the applied field and temperature. Field dependence was measured with a MFK1-A kappabridge (AGICO) applying a field variation between 5A/m and 700 A/m. Thermal change of the magnetic susceptibility during a heating-cooling cycle from room temperature to 700°C in argon was investigated using an AGICO CS-3 apparatus coupled to the MFK1 kappabridge.

• **The structure of the natural remanent magnetization (NRM)** of pilot specimens was studied using both alternating field (AF) demagnetization and thermal demagnetization (**Fig. 3**). The remanent magnetizations measurements were made with a JR-6A Dual Speed Spinner Magnetometer. On orthogonal demagnetization diagrams, individual magnetizations were identified as linear segments in both horizontal and vertical projections defined by three or more demagnetization steps. Characteristic directions were determined using principal component analysis. All accepted linear segments have maximum angular deviation (MAD) values of less than 5°. The method of Fisher, assuming circular distribution of individual magnetization directions about a true mean direction, was employed to estimate site-mean directions and associate statistics.

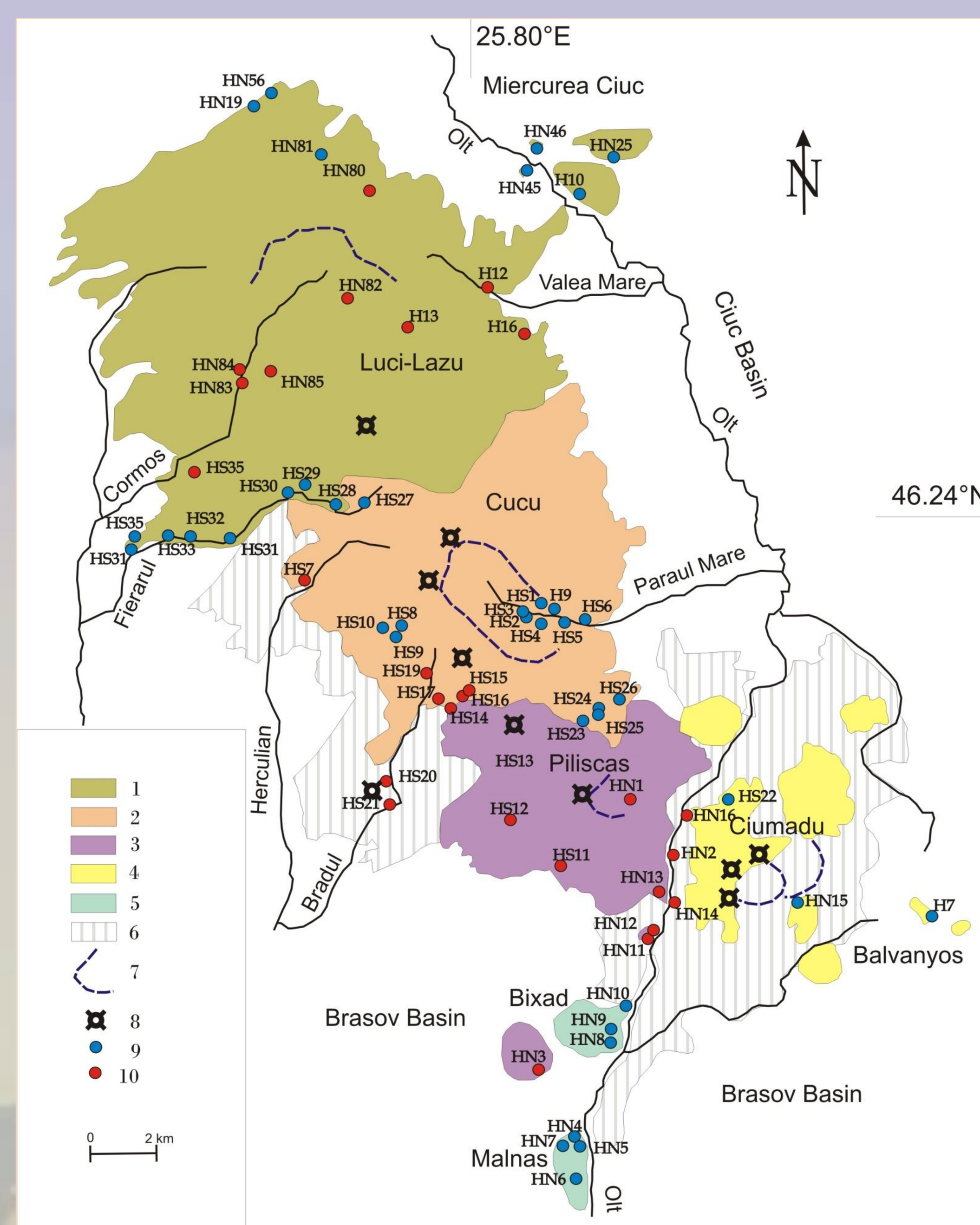

Fig. 2: Map of the South Harghita volcanic area showing the location of sampling sites. Symbols: 1) Luci-Lazu and Şumuleu-Ciuc volcanic structures; 2) Cucu volcanic structure; 3) Pilişca volcanic structure; 4) Ciumadu volcanic structure and Balvanyos extrusive domes; 4) Malnaş and Bixad intrusive domes; 7) crater; 8) eruption center; 9) sites with positive inclination; 10) sites with negative inclination. Geological map is modified after Seghedi et al. (1987).

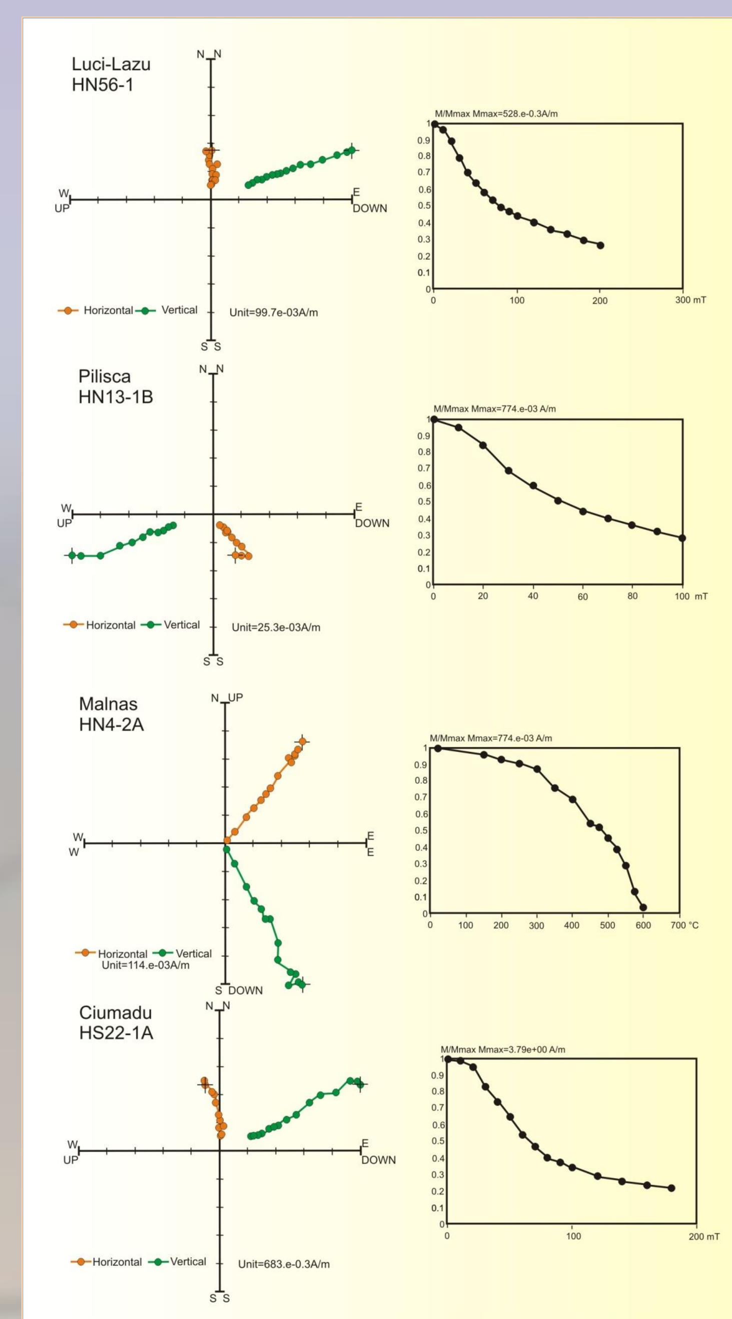

Fig. 3: Typical orthogonal diagrams and demagnetization curves of the studied samples during stepwise AF and thermal demagnetization of the NRM.

RESULTS

Both the variation of magnetic susceptibility with the applied field and with temperature show that main magnetic minerals are (low) titanomagnetite and magnetite (**Fig 4**). The structure of the NRM was identified successfully by both AF and thermal demagnetizations. Some samples are characterized by a very small viscous overprint removed up to 20 mT or 250°C. After the removal of this component vector, demagnetization plots show a linear decay toward the origin. The characteristic remanent magnetization was identified successfully in all samples. Normal polarity was identified in 39 sites, 22 sites have reversed polarity and 3 sites have intermediate directions. We rejected 4 sites because they donnot follow the data-selecting criteria of Tauxe et al., (2003).

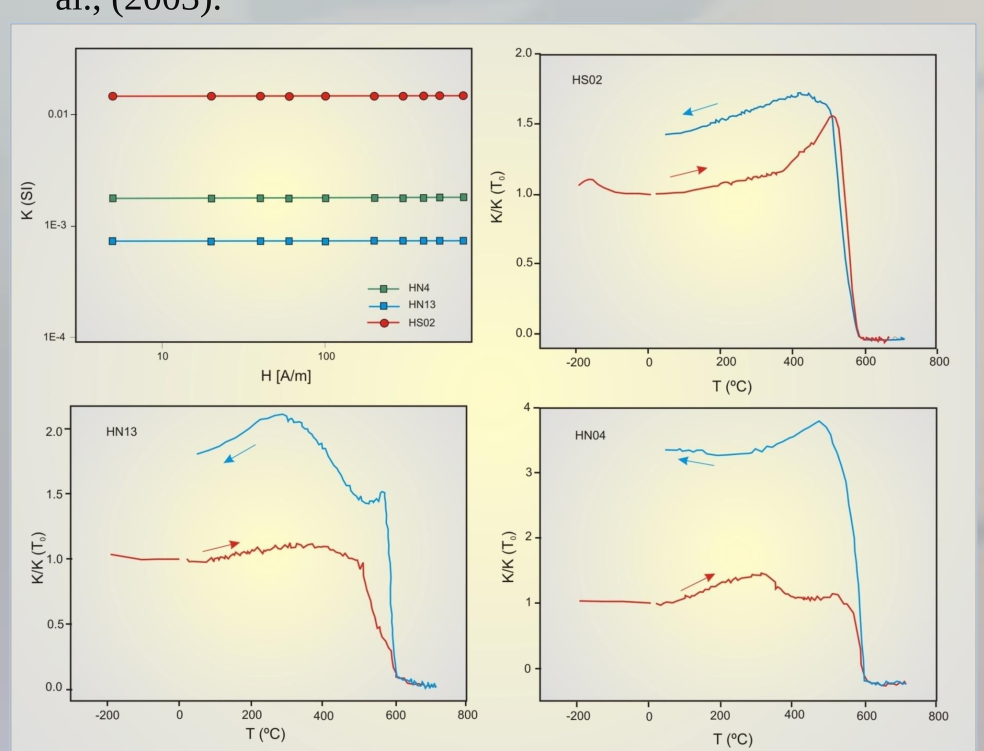

Fig. 4: Representative field and temperature dependence of magnetic susceptibility for selected specimens. Magnetic mineralogy is dominated by magnetite or low titanomagnetite.

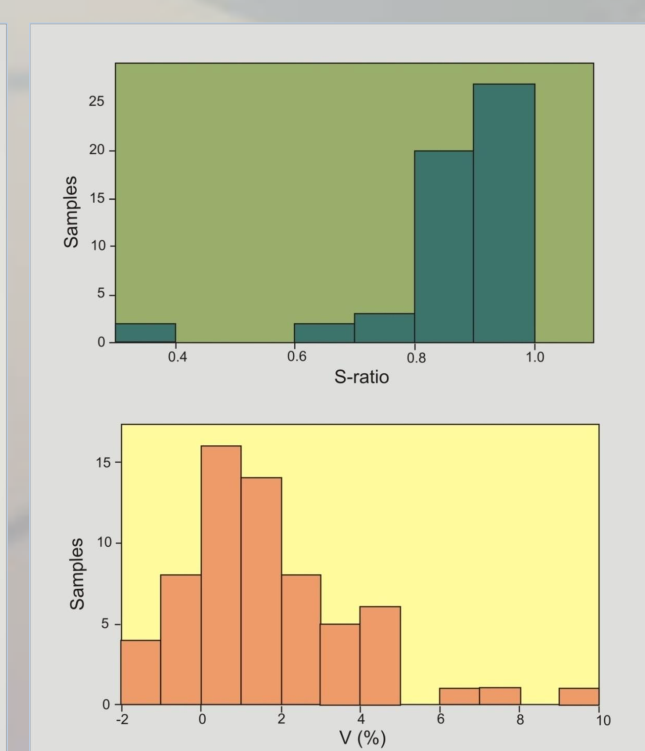

Fig. 7: Histograms of S-ratio and field dependence V for the sampled rocks.

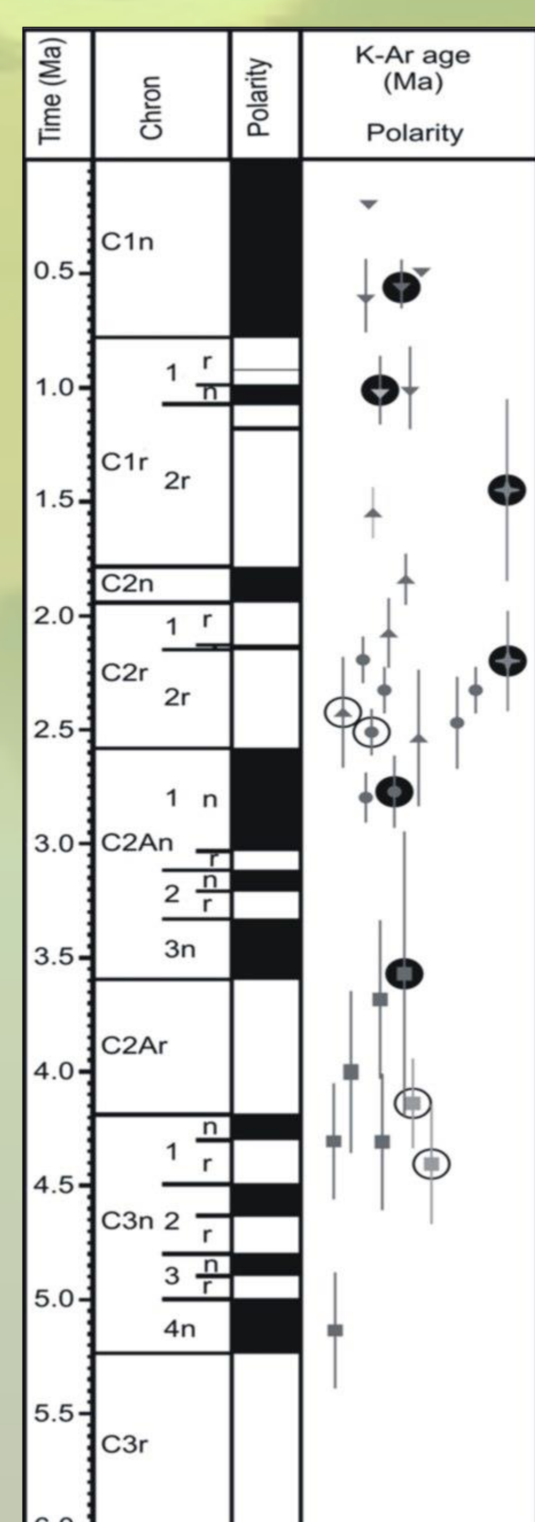

Fig 5: K-Ar ages of studied volcanic rocks: Luci-Lazu volcanic structure (squares), Cucu volcanic structure (circles), Pilişca volcanic structure (triangles), Ciumadu volcanic structure and Balvanyos dome (inverted triangles). Closed and open large circles are for dated flows with normal and reverse polarity, respectively. Geomagnetic polarity time scale after Lourens et al. (2004). K-Ar ages after Peltz et al., (1987), Pecskay et al., (1995).

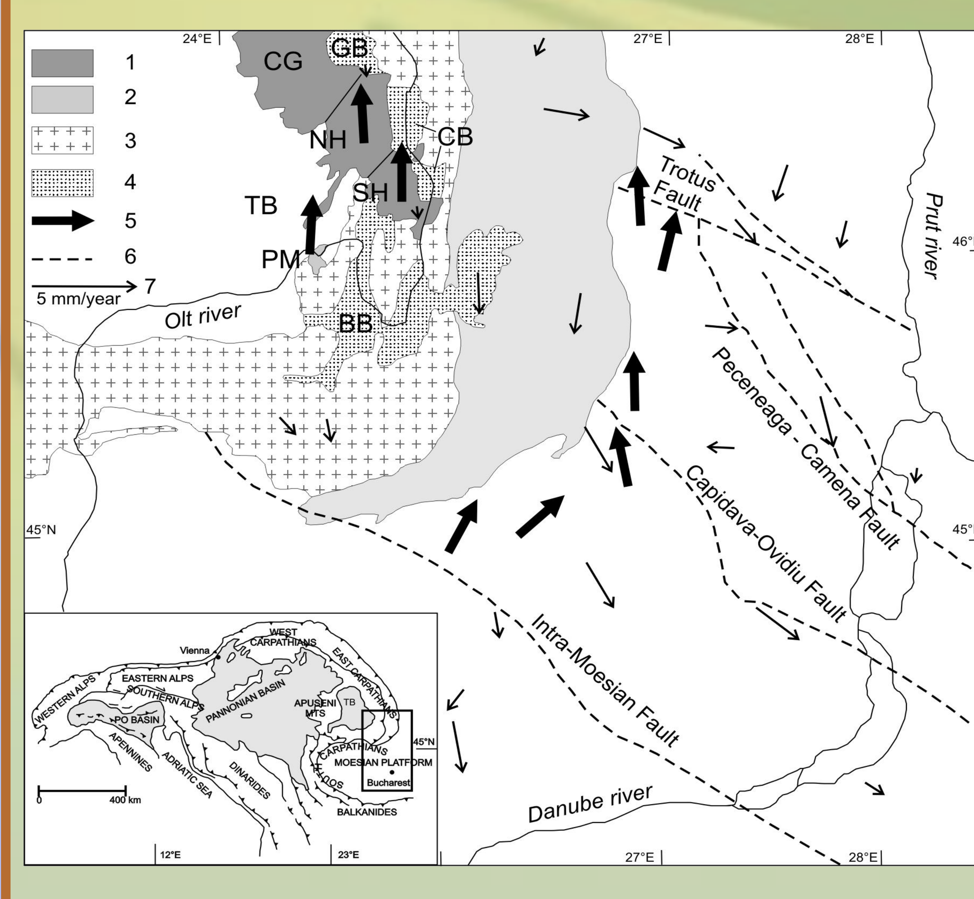

***Fig. 8**: Geological sketch (modified after Fielitz and Seghedi, 2005) showing location of the South Harghita volcanic area. Symbols: **1)** Miocene and Quaternary volcanic areas: SH = South Harghita (4.5 – 0.2 Ma); NH = North Harghita (6-4 Ma); CG = Călimani-Gurghiu (12-5.4 Ma); PM = Perşani Mountains (1.2 – 0.6 Ma) **2)** Nappes with important Miocene to Pliocene deformation; **3)** Nappes with predominat deformation in the Early Cretaceous; **4)** Miocene to Quaternary sedimentary rocks (intramontane basins): GB = Gheoghieni Basin, CB = Ciuc Basin, BB = Braşov Basin; **5)** Area-mean paleomagnetic directions (Pătraşcu, 1976; Panaiotu et al., 2004; Dupont-Nivet et al., 2005, this study); **6)** Present-day active faults in the Moesian Platform (van Hoeven et al., 2005); **7)** Horizontal GPS velocity (van Hoeven et al., 2005).*

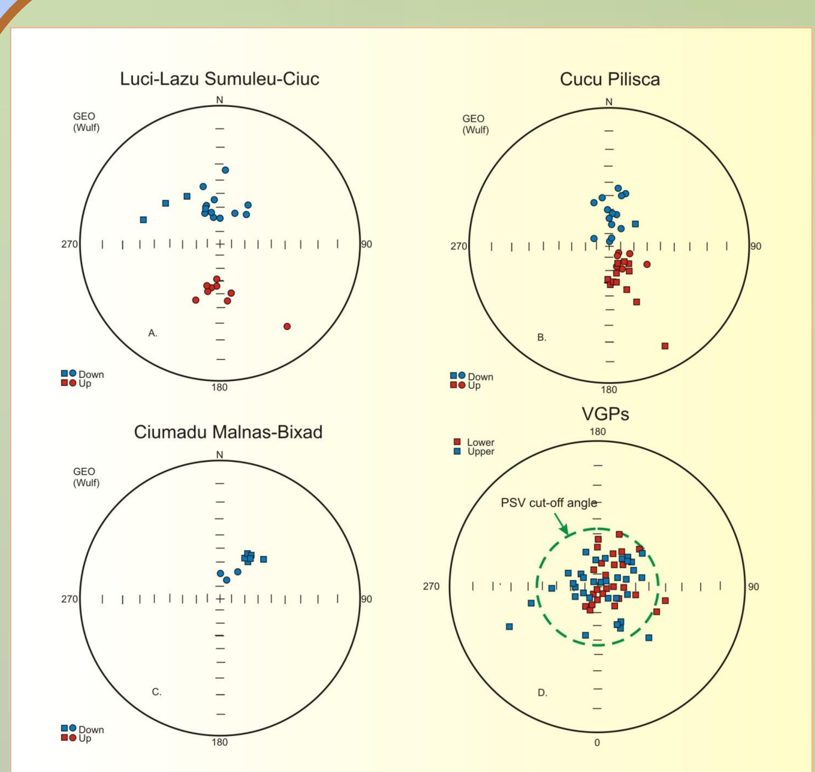

***Fig 6**: Site-mean directions and virtual geomagnetic poles (VGP) for the South Harghita volcanic area: a) Luci-Lazu volcanic structure (circles) and Şumuleu-Ciuc (squares); b) Cucu (circles) and Pilişca (squares) volcanic structures; c) Ciumadu volcanic structure and Balvanyos dome (circles) and Malnaş – Bixad domes (squares); d) VGPs of all 68 sites.*

CONCLUSIONS

Distribution of magnetic polarities in the South Harghita Mountains is in agreement with the K-Ar ages of the volcanism (Pecskay et al., 2006) (**Fig.5**). Our results are compatible with the accepted model of gradually migration of volcanic activity from north to south. Area mean direction based on 53 sites is: declination = 356° and inclination = 64° (**Fig. 6**). This result shows the absence of important vertical axis rotation during the last 4 Ma. Mean paleomagnetic declinations (Pătraşcu, 1976; Dupont-Nivet et al., 2005; this study) in the bending area of the Carpathians (thick arrows) and GPS horizontal velocities (van der Hoeven et al., 2005) are plotted in **Fig. 8**. Overall the pattern of mean paleomagnetic declinations in the last 4 Ma is compatible with the present day velocity GPS data which show intense deformation only in external part of the bending area.

Acknowledgements

This project was supported by CNCSIS grant 974/2007, grant 937/2007 and Programme PNCDI-II IDEI 151/1.10.2007

Main References:

✓ Fielitz W., Seghedi I., Late Miocene - Quaternary volcanism, tectonics and drainage system evolution in the East Carpathians, Romania. FI=1.732, *Tectonophysics 410, 111-136, 2005.*

✓ Lourens, L., Hilgen, F., Shackleton, N. J., Laskar, J. and Wilson, D. (2004). The Neogene Period. In: A Geological Time Scale (Gradstein, F. M., Ogg. J. G., Smith, A. G., eds.), Cambridge University Press, Cambridge, 409-440.

✓ Pécskay Z., Edelstein O., Seghedi I., Szakács A., Kovacs M., Crihan M., Bernad A. (1995), K–Ar datings of the Neogene-Quaternary calc-alkaline volcanic rocks in Romania. *Acta Vulcanologica*, 7: 53-63.

✓ Pecskay, Z., Lexa, J., Szakacs, A., Seghedi, I., Balogh, K., Konecny, V., Zelenka, T., Kovacs, M., Poka, T., Fulop, A., Marton, E., Panaiotu, C., Cvetkovic, V. [2006] Geochronology of Neogene magmatism in the Carpathian arc and intra-Carpathian area. *Geologica Carpathica*, 57, 6, 511-530.

✓ Peltz, S., Vâjdea, E., Balogh, K., Pécskay, Z (1987). Contributions to the chronological study of the volcanic processes in the Călimani and Harghita Mountains (East Carpathians, Romania), D.S. Inst. Geol. Geofiz, vol. 72-73/1, 323-338.

✓Seghedi, I., Downes, H., Szakács, A., Mason, P., Thirlwall, M., Rosu, E., Pécskay, Z., Marton, E., Panaiotu, C. (2004). Neogene–Quaternary magmatism and geodynamics in the Carpathian–Pannonian region: a synthesis. *Lithos* 72, 17–146.

✓ Dupont-Nivet, G., Vasiliev, I,, Langereis, C., Krijgsman, W., Panaiotu, C. [2005] Neogene tectonic evolution of the South and East Carpathians constrained by paleomagnetism. *Earth and Planetary Science Letters*, 236, 374-386

✓ Panaiotu, C. [2004] Neogene–Quaternary magmatism and geodynamics in the Carpathian–Pannonian region: a synthesis. *Lithos*, 72, 117–146.

✓ Pătraşcu S. [1976] Paleomagnetic study of some Neogene eruptive formations in the Călimani-Gurghiu-Harghita Mountains (Romania). *Rev. Roum. de Geologie Geophysique et Geographie*, 20, 51-63

✓ Michailova, N., Glevasskaya, A., Tsykora, V., Neştianu, T., Romanescu, D. [1983] New paleomagnetic data for the Călimani, Gurghiu and Harghita Volcanic Mountains. *An. Inst. Geol. Geofiz.*, LXIII, 101-111

✓Van der Hoeven, A.G.A., Mocanu, V., Spakman, W., Nutto, M. Nuckelt, A., Matenco, L., Munteanu, L., Marcu, C. and Ambrosius, B. A. C. [2005] Observation of present-day tectonic motions in the Southeastern Carpathians: Results of the ISES/CRC-461 GPS 21-36