sciendo

Geologos 30, 2 (2024): 161–163
https://doi.org/10.14746/logos.2024.30.2.14

GEOLOGOS

Reply to the comment on "Geochemistry, Rb-Sr whole rock age and Sr-Nd isotopic constraints on the Variscan A-type granite from Azegour area in the Marrakech High Atlas (Moroccan Meseta) and their geodynamic implications" by Hadani et al. (2024): Geologos 30, 1 (2024): 1–16

Mohamed Hadani[1*], Maria do Rosário Azevedo[2], Rui Dias[3], Adil Saeed[4], Salah F. Awadelsied[4]

[1]Geodynamic and Geomatic Laboratory, Department of Geology. Chouaib Doukkali University, Route Ben Maachou, B.P.20, 24.000 El Jadida, Morocco
[2]Department of Geosciences, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal
[3]Institute of Earth Sciences, Department of Geosciences, School of Science and Technology of the University of Evora, 7000-671 Evora, Portugal
[4]Department of Mineral Resources, College of Petroleum Geology and Minerals, Bahri University, Khartoum 1660, Sudan
[*]corresponding author, e-mail address: geohadani@hotmail.com

We appreciate the comments made by Loudaoued et al. (2024, this issue). This discussion allows us to elucidate some of the key issues raised by these authors (Loudaoued et al. 2024, this issue):

Despite the strongly differentiated character of Azegour granitic rock samples, their multi-element patterns reveal many similarities to those of I-type granitoids, which fact has led us to postulate that the parental liquids of A1-type were derived from partial melting of mafic magmas. We have here included additional data related to I-type magmas, taken from Brown (1990), in a comparison of multi-element patterns for the Azegour granite samples (Fig. 1).

A clear understanding of the age and geochemical characteristics of the magmatic activity in the Marrakech High Atlas MHA is required to constrain the evolution of this region during the orogenic cycle (i.e., rifting, tectonic inversion to post-collisional time), as follows:

- an early Cambrian age of the Medinet quartz diorite (Pouclet et al., 2008; Ettachfini et al., 2018; Berrada et al., 2022), or even Neoproterozoic dates of arc volcanites (Ouazzani et al., 1998, 2001);
- a Namuro-Westphalian age: U–Pb radioisotopic ages on zircon that constrain the Adassil granite emplacement (Hadani, 2009; Fekkak et al., 2017);
- Permian intrusions in the Azegour region: basic, intermediate and felsic rocks with calc-alkaline affinity (Loudaoued et al., 2023).

The dating of 275–268 Ma reflects the effects of late Variscan hydrothermal activity, because K/Ar and Rb-Sr isotopic systems are both extremely sensitive to temperature. Several mineralisations from the Marrakech High Atlas have yielded 40Ar/39Ar muscovite ages bracketed between 270 and 275 Ma

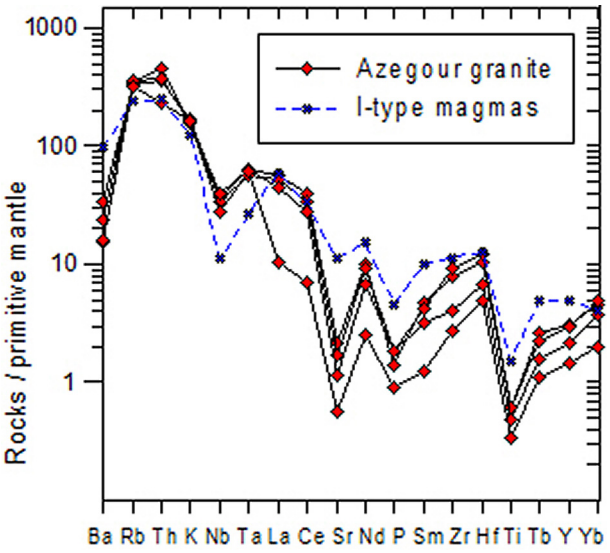

Fig. 1. Primitive mantle-normalised, multi-element patterns for the Azegour granite samples (Sun & McDonough, 1989). For comparison, I-type magmas patterns taken from Brown (1991), are included.

(Chauvet et al., 2002). It is therefore highly likely that the 40Ar/39Ar low temperature plateau age does not provide a date for the emplacement of the Medinet intrusion (Hadani et al., 2007). Consequently, it is not possible to exclude the presence of a hidden pluton (evolved melt/mush) of the same composition as that of Azegour in the region (Boukerrou et al., 2018; Taib et al., 2020; El Khalile et al., 2023; Jinari et al., 2023; Loudaoued et al., 2023).

Two granitic samples (leucogranites) from the Tichka complex show geochemical similarities to the Azegour granite. These leucogranites are geologically younger than the other intrusions (Gasquet, 1991).

We propose further studies using further analytical techniques and procedures that have been developed in order to evaluate mixing or unmixing (fractional crystallisation) in geological systems (e.g., Vogel et al., 2008).

References

Berrada, I., Fekkak, A., Pereira, M.F., Jouhari, A., Ouanaimi, H., Leprêtre, R., Ezzouhairi, H., Gasquet, D., El Attari, A. & El Houicha, M., 2022. Geochronological evidence of Cambrian Series 2 calc-alkaline plutonism in the Paleozoic Western High Atlas (Moroccan Meseta). *Journal of African Earth Sciences* 194, 104611.

Boukerrou, S., Nalini, H., Moreira, H., Maacha, L., Zouhair, M., Outhounjite, M., Ouirouane, S., Hibti, M. & Touil, A., 2018. Geochronology and geochemistry of Ediacaran volcanic rocks of the Tighardine ore deposit formation (western High Atlas, Morocco). *Arabian Journal of Geosciences* 11, 1–24.

Brown, M., 1991. Comparative geochemical interpretation of Permian-Triassic plutonic complexes of the Coastal Range and Altiplano (23°30′ to 26°30′S), northern Chile. *Geological Society of America, Special Paper* 265, 157–171.

Chauvet, A., Barbanson, L., Gaouzi, A., Badra, L., Touray, J. C. & Oukarou, S., 2002. Example of a structurally controlled copper deposit from the Hercynian western High Atlas (Morocco): the High Seksaoua mining district. *Geological Society, London, Special Publications* 204, 247–271.

El Khalile, A., Aissa, M., Touil, A., Hibti, M., Loudaoued, I. & Bilal, E., 2023. Evolution of ore-forming fluids at Azegour Mo-Cu-W Skarn Deposit, Western High Atlas, Morocco: Evidence from mineral chemistry and fluid inclusions. *Minerals* 13, 1537.

Ettachfini, E.M, Fekkak, A., Ouanaimi, H., Jouhari, A., Ezzouhairi, H., Ettachfini, M., Hilali, M. & Michard, A., 2018. *Carte Géologique du Maroc au 1/50000, Feuille Azegour – Notice explicative*. Notes et Mémoires de Service Géologique du Maroc 589 bis. 111 pp.

Fekkak, A., Ouanaimi, H., Ettachfini, E.M., El Arabi, H., Jouhari, A., Aarab, A. & Baidder, L., 2017. *Carte géologique du Maroc (1/50.000), Feuille Amezmiz*. Notes et Mémoires de Service Géologique du Maroc 588.

Gasquet, D., 1991. *Genèse d'un pluton composite tardihercynien: le massif du Tichka, Haut Atlas occidental (Maroc)* [*Genesis of a Late Hercynian composite pluton: the Tichka massif, Western High Atlas (Morocco)*]. Université Nancy I, France, 413 pp.

Gasquet, D., Leterrier, J., Mrini, Z. & Vidal, Ph., 1992. Petrogenesis of the Hercynian Tichka Plutonic Complex (Western High Atlas, Morocco): trace element and Rb-Sr and Sm-Nd isotopic constraints. *Earth and Planetary Science Letters* 108, 29–44.

Hadani, M., 2009. *Evolução tectono-metamórfica e magmática do sector setentrional do Alto Atlas ocidental (Marrocos)* [*Tectono-metamorphic and magmatic evolution of the northern sector of the Western High Atlas (Morocco) in the Variscan Ibero-Moroccan frame*]. Evora University, 267 pp., https://dspace.uevora.pt/rdpc/handle/10174/11112.

Hadani, M., Rosário Azevedo, M. & Dias, R., 2007. *40Ar-39Ar amphibole ages for the Medinat Variscan granitoids (Western High Atlas, Morocco); geodynamical implications*. IGCP Meeting & Field Workshop, El Jadida, Morocco, 76–77 pp.

Hadani, M., Rosário Azevedo, M., Dias, R., Saeed, A. & Awadelsied, S.F., 2024. Geochemistry, Rb-Sr whole rock age and Sr-Nd isotopic constraints on the Variscan A-type granite from Azegour area in the Marrakech High Atlas (Moroccan Meseta) and their geodynamic implications. *Geologos* 30, 1–16.

Jinari, A., Rddad, L., Mouguina, E.M. & Ouadjou, A., 2023. Origin of the Amensif Zn-Cu (Pb-Ag-Au) distal skarn deposit (Western High Atlas, Morocco): Constraints from COS isotopes. *Journal of African Earth Sciences* 199, 104850, https://doi.org/10.1016/j.jafrearsci.2023.104850

Loudaoued, I., Touil, A., Aysal, N., Aissa, M., Keskin, M., Yılmaz, İ. & Ouadjou, A., 2023. Volcanic rocks from Amensif-Tnirt district in the western High Atlas (Morocco): Geochemistry, magma features and new age dating. *Journal of African Earth Sciences* 205, 104975. https://doi.org/10.1016/j.jafrearsci.2023.104975

Loudaoued, I., Elbakhouch, N., Touil, A., Aissa, M. & Aysal, N., 2024. Comment on "Geochemistry, Rb-Sr whole rock age and Sr-Nd isotopic constraints on the Variscan A-type granite from Azegour area in the Marrakech High Atlas (Moroccan Meseta) and their geodynamic implications" by Hadani et al. (2024): Geologos 30, 1 (2024). *Geologos* 30, 157–160.

Ouazzani, H., Badra, L., Pouclet, A. & Prost, A.E., 1998. Mise en évidence d'un volcanisme d'arc néoprotérozoïque dans le Haut-Atlas occidental (Maroc) [Evidence of Neoproterozoic arc volcanism in the western High Atlas (Morocco)]. *Comptes Rendus de l'Académie des Sciences – Series IIA - Earth and Planetary Science* 327, 449–456.

Ouazzani, H., Pouclet, A., Badra, L. & Prost, A., 2001. Le volcanisme d'arc du massif ancien de l'ouest du Haut-Atlas occidental (Maroc), un temoin de la convergence de la branche occidentale de l'ocean panafricain [Arc volcanism of the ancient massif of the western High Atlas (Morocco), a witness to the convergence of the western branch of the Pan-African Ocean]. *Bulletin de la Société Géologique de France* 172, 587–602. https://doi.org/10.2113/172.5.587

Pouclet, A., Ouazzani, H. & Fekkak, A., 2008. The Cambrian volcano-sedimentary formations of the westernmost High Atlas (Morocco): their place in the geodynamic evolution of the West African Palaeo-Gondwana northern margin. *Geological Society, London, Special Publications* 297, 303–327.

Sun, S.S. & McDonough, W.F., 1989. *Chemical and isotopic systematics of oceanic basalts: Implications for mantle composition and processes*. [In:] Saunders, A.D. & Norry, M.J., (Eds): Magmatism in the ocean basins. Geological Society, London, Special Publications 42, 313–345.

Taib, Y., Touil, A., Aissa, M., Hibti, M., Zouhair, M. & Ouadjou, A., 2020. Geochemistry and petrogenesis of early Ediacaran volcanic rocks from Taourirte district (Western High Atlas, Morocco): Origin and geodynamic implications. *Journal of African Earth Sciences* 170, 103936.

Vogel, T.A., Hidalgo, P.J., Patino, L., Tefend, K.S. & Ehrlich, R., 2008. Evaluation of magma mixing and fractional crystallization using whole-rock chemical analyses: Polytopic vector analyses. *Geochemistry, Geophysics, Geosystems* 9, Q04020. https://doi.org/10.1029/2007GC001790

Manuscript submitted: 25 July 2024