DIPARTIMENTO
DI SCIENZE DELLA TERRA
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DOTTORATO DI RICERCA
IN SCIENZE DELLA TERRA

Research activity (max 1.000 words):

Introduction and state of the art

The geological history of Iran is linked to the evolution of Tethyan Ocean [3]. The Iranian plate contains a number of continental fragments that have been welded together along a NW-SE-directed suture zone. This suture zone resulted after the total consumption of the Neotethys Ocean, which was subducted NE-ward beneath Iran during Early to Late Cretaceous time. The subsequent collision of Arabia against Iran in the Late Cretaceous time influenced the geological evolution of Iran. Zagros Orogenic Belt represents the result of this convergence and it is considered one of the most important sectors of Alpine-Himalayan Belt, despite being the less known portion.
Structurally, from NE to SW, The Zagros Orogenic Belt can be divided into three parallel tectonic sectors: (1) the Urumieh-Dokhtar Magmatic Arc (*UDMA*), a subduction-related magmatic arc composed of Eocene to Quaternary tholeiitic to calcalkaline and K-rich alkaline lavas, in some cases also with adakitic affinity [5, 10]; (2) the Sanandaj-Sirjan Zone (*SSZ*), a metamorphic belt composed of mainly Mesozoic [1]; and (3) the Zagros Fold-and-Thrust Belt (*ZFTB*; Fig.1), the external part of the orogen which consists of folded and faulted rocks mainly of Paleozoic and Mesozoic age [1, 2, 4]. This orogenic belt formed during the NE-directed subduction of the Neotethyan oceanic realm and the subsequent oblique collision of Gondwana (Arabia) with the Iranian micro-continent in Late Cretaceous-Early Tertiary times [1, 2, 9]. The convergence continued and became more intense in the Pliocene and is still active. Despite the crucial role of the study area in understanding the evolution of the Alpine-Himalayan Orogeny, as well as in the reconstruction of the Neotethys paleogeography, Iran is still poorly studied. In the recent years, as a result of extensive geological mapping in various segments of the internal and external parts of the orogen, a better understanding of the evolution of this mountain belt has emerged [2]. With the new political framework, the study of this country, especially in scientific collaboration with local universities, it will be a great occasion and a unique opportunity to build good science.

Specific objective and goal

The development of a petrogenetic model of the Cenozoic magmatism in Iran is the general goal of this research. The main goal will be reached through the petrographic, mineral chemical, geochemical and Sr-Nd-Pb isotopic analyses of more than 200 rocks from the Urumieh-Dokhtar Magmatic Arc (Fig.1).

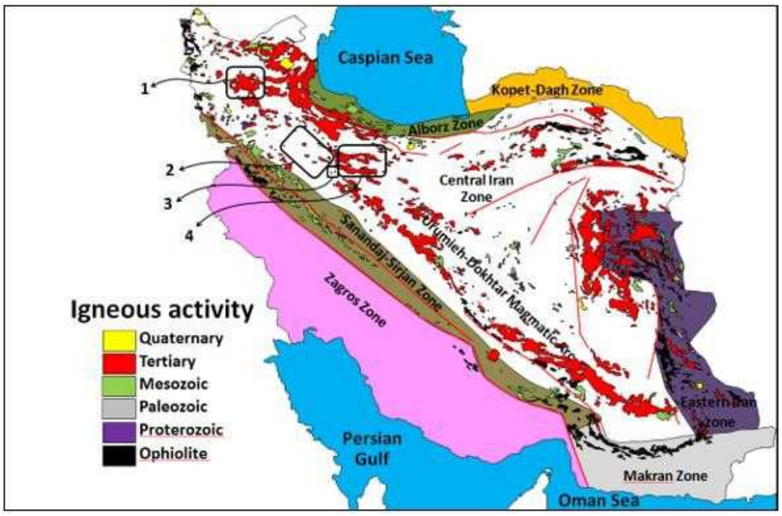

Fig. 1: Geographic distribution of the collected igneous rocks in Iran. (1) Sahand; (2) Qorveh; (3) Nawbaran; (4) Tafresh.

Despite the widespread distribution of igneous rocks, little is known on the Cenozoic igneous activity in Iran. Through an exhaustive review of all the existing data and the production of new and original data, possibly involving also non-conventional isotopic studies (e.g., Li, Mg, B, coupled with the more common Sr-Nd-Pb-Hf-O isotopes) I shall shed light on such an important magmatic phase in collaboration with dr. Samuele Agostini of CNR-IGG (Pisa).
Experimental petrology studies on peculiar rock compositions (melilitites to nephelinites) are scheduled in the HP-HT laboratory of INGV of Rome to constrain their chemical composition of the mantle source, the role of carbonates and their origin in a subduction-related setting. All the data will be put in a regional structural framework, inferring the geodynamic setting, the causes of igneous activity and the dynamics of the upper mantle during a collisional event.

Study areas

The Sahand Volcano is situated in NW Iran, located south of the Tabriz Fault within the northern part of the Urumieh-Dokhtar magmatic arc (n. 1 in Fig. 1). The Sahand volcano covers an area of ~7200 km^2 (more than four times the area of Mt. Etna) and reaches a maximum elevation of 3600 m above sea level. Volcanic rocks consist of a wide range of pyroclastics and lavas (Fig. 2). Three distinct types of magma that erupted during three different periods have been identified: (1) calcalkaline andesites at 12-9 Ma; (2) calcalkaline dacitic magma at 10-5 Ma; and (3) alkaline andesitic and dacitic magma of Quaternary age [5]. Despite the huge size of the volcano, the geochemical, mineralogical and isotopic composition of its products is unknown.

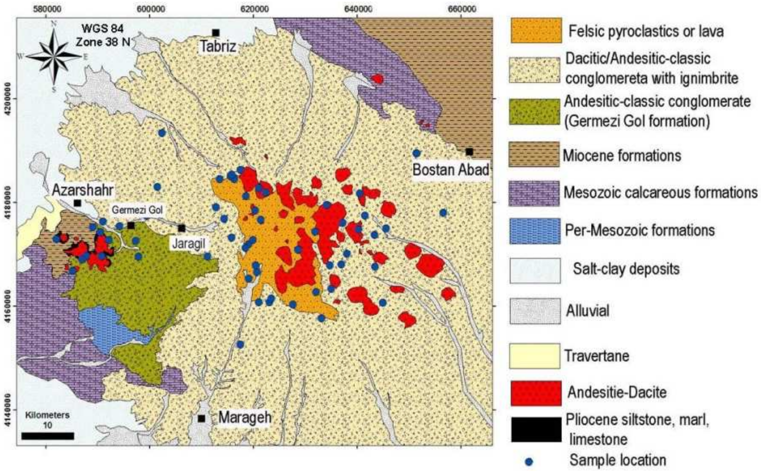

Fig. 2: Geological map of the Sahand Volcano.

<u>The Qorveh area</u> is located South of Bijar (Fig. 3). Two phases of volcanism have been identified. The first (9-8 Ma) is represented by dacitic-rhyolitic domes and pyroclastic deposits [5]. These high-K calcalkaline rocks are considered the final stage of the Eocene andesitic activity of the UDMA. The second (1.3-0.5 Ma) is characterized by strongly SiO2-undersaturated alkaline ~~spatter,~~ cinder cones and lavas [5]. The contemporaneous presence of rhyolites and basanites is considered the proof of the occurrence of different sources [5]. Also in this case the composition of these products is poorly known.

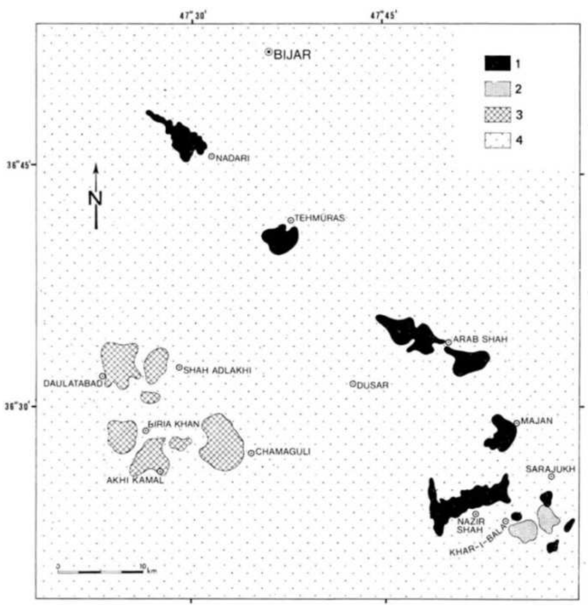

Fig. 3. Map of volcanic rocks in the Bijar area. 1, Pleistocene basic volcanic rocks; 2, Pleistocene acid domes; 3, Upper Miocene acid domes; 4, Neogene and Quaternary sediments. From Boccaletti et al. (1977).

<u>The Nawbaran volcanoes</u> are located between Saveh and Kabodarahang villages (Fig. 4a). The activity of these small volcanoes is characterized by a first phase of lava flows, followed by scoriaceous pyroclastic deposits (10% of the total volume). These rocks are classified as melilites and nephelinites, rare compositions in Iran and in subduction zones. Their occurrence represent an

interesting case of study about the genesis of carbonatitic magmas in subduction zones. It allows experimental investigations about the deep cycle of carbon, about its presence in different phases into the mantle and its role in petrogenetic processes.

The Tafresh area is located S of the Nawbaran zone (Fig. 4b). It is characterized by the occurrence of Late Oligocene calcalkaline and SiO_2-oversaturated adakitic volcanic rocks, followed by calcalkaline basalts (34.6 Ma), Nb-Ta-enriched basalts from W Kashan (19.1 Ma) and dacitic adakite from W Nain (14.1 Ma) [6]. The occurrence in W Nain of Nb-Ta-enriched and depleted basic magmatism followed by SiO_2-undersaturated adakites is interpreted as the evidence of an asthenospheric mantle upwelling triggered by a slab retreat [6].

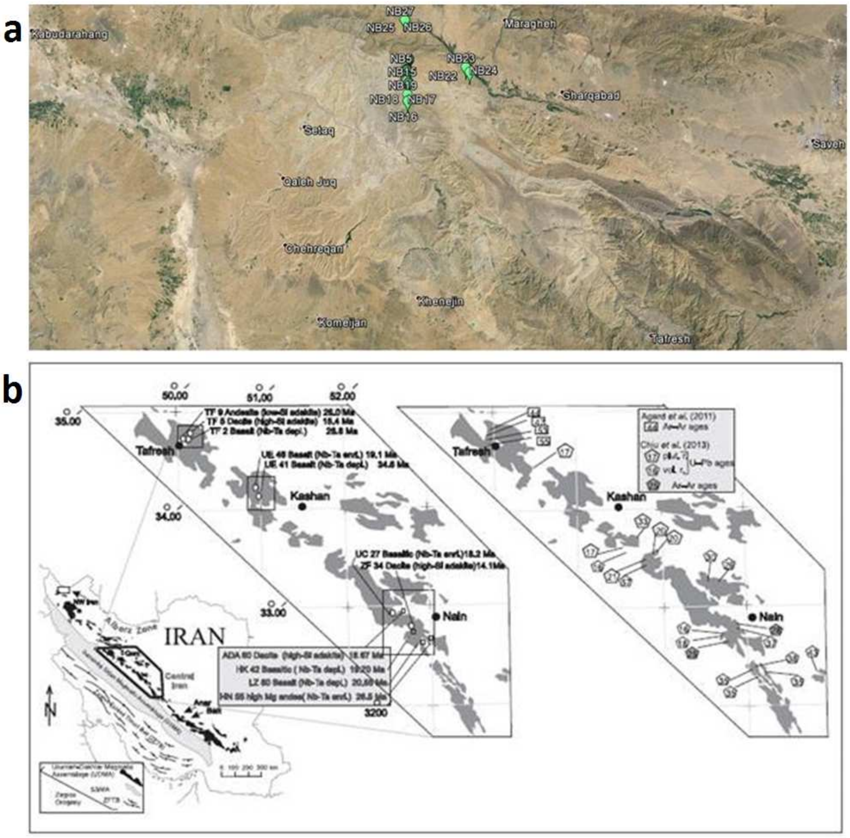

Fig. 4. (a) Nawbaran area: green symbols represent the rock samples. From Google Earth. (b) Location of igneous rocks in Tafresh, Kashan and Nain areas. From Ghorbani et al. (2014).

Development of the research activities

The samples collected during previous field excursions have never been processed. In case of difficulties to organize a fieldwork in Iran, the samples already available are sufficient to present robust petrogenetic models. Anyway, one field-trip activity is scheduled in the area in order to get a new sampling campaign that will be carried out in collaboration with researchers from University of Tabriz (dr. Ghazi) and Tehran (prof. Masoudi, dr. Rahmizade and prof. Ghorbani).
By the end of the first year I expect to conclude thin section preparation and petrographic description of the samples already available. By the end of the second year I expect to conclude quantitative

whole-rock chemical analysis (major and trace elements), the electron microprobe (EMP) work as well as the Sr-Nd-Pb isotopic measurements in the CNR laboratories of Pisa. I am also evaluating the possibility to analyze uncommon isotopic systematics in Pisa laboratories. Furthermore, C-O-H isotopic measurements are provided to be held at the CNR laboratories of Rome, and the laser ablation microprobe-inductively coupled plasma-mass spectrometry (LAM-ICP-MS) at Pavia (in collaboration with dr. Zanetti) or Perugia (in collaboration with dr. Perugini). Experimental studies on magma formation and evolution will be carried out at the HP-HT laboratory of INGV in Rome in collaboration with dr. Vincenzo Stagno.
A new analytical technique will be experimented in the laboratories of the Dipartimento di Scienze della Terra of Sapienza University, with the development of a voltaic arch producing small glassy beads to be inglobed in epoxy resin, polished and analyzed for major and trace elements (EMP and LAM-ICP-MS). The voltaic arch has already demonstrated to work, with results published in two articles [7, 8] and my activity will be only to improve its efficiency, working in Ar-controlled atmosphere.
A selection of samples will be also chosen for $^{40}Ar/^{39}Ar$ dating at Technische Universität Freiberg (Germany), in collaboration with dr. Jörg Pfänder at the Technische Universität Freiberg laboratories.
Furthermore I'm going to participate to the "3rd European mantle workshop" that will be held in Pavia (June 2018) and to the Congress "Cities on Volcanoes" in Naples (September 2018). Moreover I'm interested to take part to the "Etna International Training School of Geochemistry" (in Sicily in summer 2018) and I would like to attend the Goldschmidt Conferences in the next years.
The participation to meeting and conference organized by the Italian Group of Petrography (GNP) and Italian Society of Mineralogy and Petrology (SIMP) represents a good tool of comparison and dissemination.

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