Geochronology and Petrogenesis of the Late Cretaceous Ambohiby and Bevato intrusive complexes (central Madagascar)

Tutor: Ciro Cucciniello Co-tutor: Leone Melluso

The Madagascar is a key area to reconstruct the paleogeography of Gondwana supercontinent, due to its location, in the area between India, Africa and Antarctica. Madagascar has a long geological history and a unique assemblage of life forms that differ from those on other continents. The metamorphic rocks of the Madagascan basement have tectonic, stratigraphic and lithological similarities with those of the neighbouring lands. The sedimentary basins of western Madagascar have the same stratigraphic evolution with those of East Africa, at least up to Jurassic times, being both part of the Karoo system, active until Paleozoic times.

The Large Igneous Province (LIP) of Madagascar is one of the largest magmatic events in the Late Cretaceous. Remnants of this igneous province crop out along the rifted margin of the eastern coast, in the Mahajanga and Morondava basins of western Madagascar and directly above the Precambrian basement and comprise lava flows, dikes, sills and intrusive complexes. The original pre-erosion extent of the province is likely exceeded 1×10^6 km^2. The origin of Madagascar LIP is postulated to be linked to both Madagascar-Greater India rifting and the Marion plume. The available age determinations indicate a time span of about 8 Ma for the emplacement of the LIP (92-84 Ma) with the youngest products located to the south.

This implies the following: a) the bulk of the LIP is slightly older than the first known oceanic crust of Mascarene basin (83.6 Ma); b) this age range is very close to a well-known oceanic anoxic excursion (OAE-2; 93 Ma) associated with significant climate change and as recorded in pelagic sediments and tephra, thus suggesting some link between the two geological features. Furthermore, igneous rocks of southern India have ages of ~90-85 Ma, thus suggesting a link between the two volcanic areas.

Sparse studies of the volcanic rocks of Madagascar highlight the peculiar chemical and isotopic compositions of these rocks. These are mainly mafic tholeiitic rocks, with lower amounts of more evolved dacites and rhyolites, these latter mainly formed after open system fractional crystallization of basalt parents. Alkaline rocks are subordinate, and mostly in the form of dikes or rare intrusive complexes (Antampombato-Ambatovy), and in the Ejeda-Bekily dike swarm. Peralkaline silicic rocks are known at the Androy complex and Antampombato.

In this framework, the geochemical and isotopic variations of the mafic rocks evidence the extreme heterogeneity of the feeding systems from typical MORB composition found in dikes of western coast, and compositions clearly the result of important interaction with continental crust or lithospheric mantle (NW Madagascar basalts, Androy, Ejeda-Bekily swarm).

The consequence of this geochemical and isotopic heterogeneity is the lack of reliable indications of mantle sources different from those forming MORB. It is well known that one of the most important hypotheses for the genesis of the LIPs is upwelling and melting of a mantle different from that of typical asthenosphere, likely coming from deeper regions of the mantle. Evidence of the hot spot hypothesis should be seen in the track of volcanic islands, of which the most recent is the Marion-Prince Edward archipelago in the southern Indian Ocean. Deep mantle sources should have characteristic isotopic signatures, to be observed in the magmas, but no trace of deep source signatures have seen in the Madagascan basalts. Even primitive mafic rocks erupted very close to the presumed position of the hotspot at 88 Ma only show geochemical characteristics typical of lithospheric mantle or even the crust.

The aim of this project is to propose a likely scenario for the origin of Madagascar LIP.

A detailed study of the chemical and isotopic composition of igneous rocks and a chemical characterization of the minerals will be carried out in order to identify compositional trends, equilibrium assemblages, characteristics of mantle source and potential contaminants.

Geochemical studies on the partitioning of trace elements between melts and coexisting minerals using LA-ICPMS will be performed in order to identify the geochemical characteristics of parental magmas. Thermodynamic variables that rule the magmatic evolution in the different volcanic areas (e.g. temperature, pressure) will be determined through phase equilibrium studies on coexisting minerals and bulk-rocks.

A robust and precise geochronological framework would allow to understand the causes and effects of Madagascar LIP. A prerequisite to establishing a causal relationship between volcanism and climate change is the relative timing of the two events. Moreover, the timing between the Madagascar LIP emplacement, rifting and the subsequent oceanization process is crucial for the Gondwana breakup reconstruction. With advances in radiometric dating, a much more precise picture of the age and duration of eruption of large igneous provinces is emerging.

Precise timing and duration of magmatic activity are fundamental to evaluate linkages between LIP emplacements and environmental events.

Proposal for a PhD position

A doctoral position will be applied for a candidate who can carry out research on Madagascar LIP project. In particular, the PhD project will focus on the petrogenesis of Late Cretaceous intrusive complexes (Ambohiby and Bevato, central Madagascar) and should be completed within three years. The work programme will include the study of the available literature and a selection of samples collected during several field trips in Madagascar. The PhD project is articulated in three working packages including a textural characterization, XRF, ICP-MS and Nd-Sr-Pb determination on whole-rock, a detailed in-situ geochemical study using EMPA and LA-ICP-MS; Ar-Ar and U-Pb ages of mineral separates. The analytical programme will be performed by using the instrumental facilities at the DiSTAR (University of Napoli Federico II), where the PhD student will have the possibility to acquire technical skills in mineralogical, and petrographic methods, such as chemical analysis (XRF), polarised light and scanning electron microscopy with

microanalysis (EDS/WDS), and Sr-Nd-Pb isotope analysis. Training courses of the "Scuola di Dottorato" will be also available for the student at the host University for improving its knowledge on different topics.

A period of about 5 months for a visiting fellowship abroad is also included in the work programme for the PhD student to learn different analytical methods (LA-ICP-MS, Ar-Ar and U-Pb) and to make useful discussion with other scholars, to have the possibility to develop further its career.

Projects

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Duration 36 months