Introduction: LASI III—Magma pulses and sheets in tabular intrusions

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FOREWORD

The origins of granites and intrusive rocks have been widely discussed for a couple of centuries, and the way volcanoes work and their magma forms have attracted scientists, naturalists, and laymen since the dawn of humankind. However, shallow igneous intrusions, representing the obvious link between the hidden kingdom of Pluto and the fiery realm of Vulcanus, have been partly overlooked, leading to some lack of communication between "plutonic" and "volcanic" researchers. An effort devoted to heal this breach has been contributed to by the establishment of the LASI conferences (named after laccolith and sill, the main types of shallow igneous intrusions).

LASI CONFERENCES

The LASI I conference was held at Technische Universität Bergakademie, Freiberg (Germany), in October 2002, and a collection of papers was published in a volume edited by Breitkreuz and Petford (2004).

The LASI II conference was held in Skye (Scotland) in April 2006, and related papers were published in a volume edited by Thomson and Petford (2008).

The LASI III conference was held in September 2008 on Elba Island (Tuscany, Italy), and was intended to continue and update the discussion of emplacement mechanisms of shallow tabular intrusions, extending the debate to magma chemistry and the relationships between intrusive history and regional geology. A two-day field trip was devoted to some of the youngest (Late Miocene) plutonic-subvolcanic complexes in Europe. Participants visited a nested felsic Christmas-tree laccolith complex (Fig. 1), a major sheeted pluton, a mafic dike swarm, and a felsic-aplitic dike swarm coupled with classic ore mineral deposits. Lively discussions that arose during both the presentation of the 40 papers (abstracts available at http://www.dst.unipi.it/dst/rocchi/LASI3) and the field trip, made the participants more aware of the links between the following four main topics related to shallow tabular intrusions.

MAIN TOPICS

Geophysical Imaging of Sheet Intrusions

Subvertical sheet-like igneous intrusions represent the main pathway for magma ascent through the brittle crust. However, subhorizontal sheet intrusions constitute a main, yet underexplored, reservoir for magma emplaced in the shallow crust. The occurrence of these intrusions in passive margin basins that are heavily explored for hydrocarbons has granted scientists access to a wealth of costly geophysical data. In recent years, the traditional potential of seismic investigations has been greatly increased by detailed three-dimensional seismic imaging integrated with gravity and magnetic data. Significant advancements have been made in our knowledge of the shapes of these intrusions (e.g., saucer-shaped sills), their mode of inflation, and their influence on host sediments that are disrupted to generate hydrothermal venting with possible climatic influences.

Volcanic Systems

Our understanding of volcanic plumbing systems greatly benefits from studies of shallow-level intrusions, i.e., feeder dikes and sheeted chambers. It is noteworthy that several recent works indicate that magma feeding in shallow intrusions can be very fast and, conversely, that pre-eruptive histories of magma batches can be as long as 200 ka. Shallow-level intrusions can be envisaged as magma chambers that, in some cases, fed large eruptions, while in other instances became the graveyards of an entire magma supply. The shape of magma chambers, their internal zoning along with the reactions zones of surrounding country rock, their replenishment-feeding histories, and their geochemical evolution can shed light on mechanisms generating both geological hazards such as catastrophic eruptions, and geological resources such as ore deposits.

Plutonic Systems

A wealth of multidisciplinary data (including field mapping, structural geology, mineral chemistry, petrology, geochemistry, gravity, magnetic, and anisotropy of magnetic susceptibility) indicates that many igneous bodies grow by the amalgamation of successive magma

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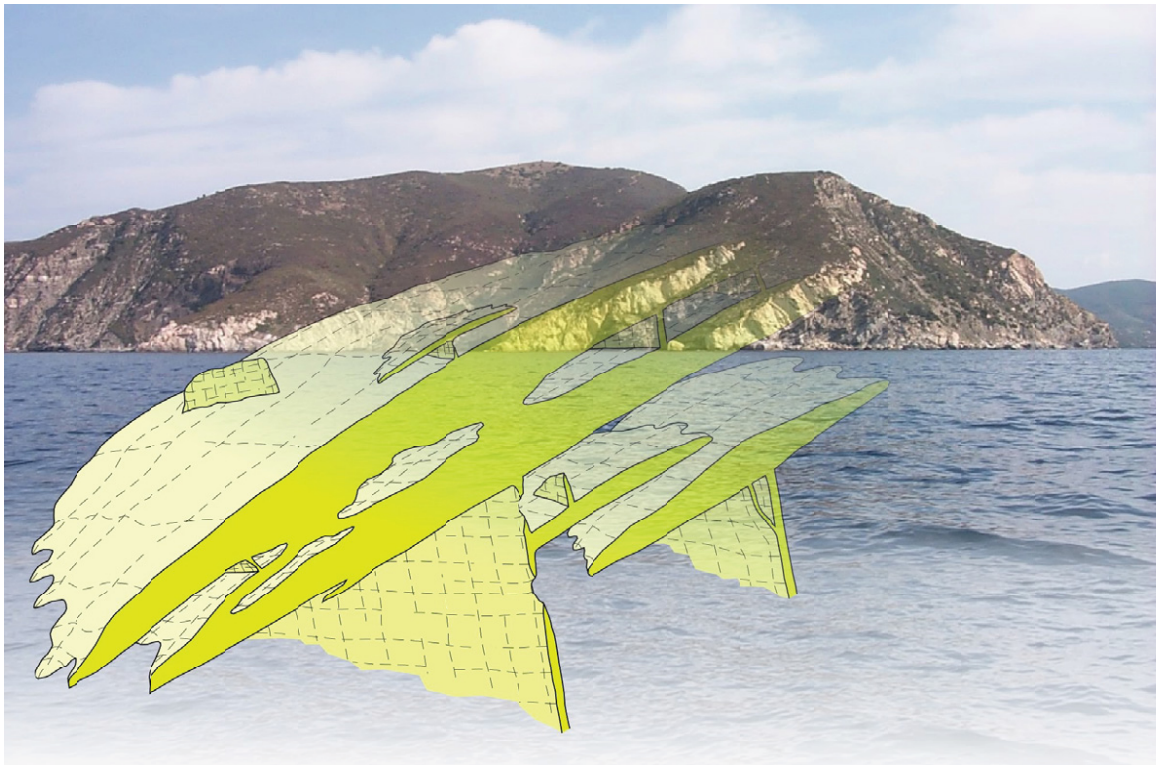

Figure 1. Conceptual scheme of the western-central Elba Laccolith Complex, with a line drawing of a Christmas-tree laccolith over a panoramic view of laccolith layer terminations (as seen during a boat trip during the LASI III conference). Vertical relief of the cliff is 300 m.

pulses, often emplaced as either subvertical or subhorizontal sheets (i.e., multipulse sheeted plutons), the latter possibly built up as adjoining magma fingers and lobes. The time intervals and evolving thermal state between pulse emplacements strongly affect the success of the different methods of investigation used to unveil multiple magma pulses. Efforts in isotope chronology can be either illuminating or frustrating if the time intervals between pulses are long or short, respectively. The search for solid-state fabrics is useful when early pulses cool sufficiently before the arrival of the following magma pulse. Petrographic and/or geochemical identification of magma batches can succeed if the batches are geochemically diverse and did not mix thoroughly at the emplacement site. Hidden pulses can be unveiled by geophysical investigations if the density or magnetic contrast between solidified magma batches is large.

Dikes, Sills, and Tectonic Regime and/or Setting

Dikes are commonly considered evidence for pathways of magmas ascending through the crust. They offer the potential to reconstruct stress fields at the time of diking because they directly record the strain associated with their emplacement. Possible stress-related inferences include the degree of coaxiality with respect to the near-field boundary conditions; this in turn relates to whether the deforming system is compressive, tensional, transpressive, or transtensional. Several factors influence the geometry and the structural patterns of magma pathways: (1) the structure of the crust (presence and attitude of old discontinuities such as bedding and thrust faults) and its rheological heterogeneities; (2) regional stress fields in the area at different crustal levels; and (3) magma driving pressure. Emplacement of multiple intrusions introduces additional transient factors to the local stress field. All these factors contribute in differing degrees to producing the final spatial distribution of dikes in plutonic-subvolcanic systems.

CONCLUSION

The liveliness of the LASI Conference series is attested to by the planned LASI IV conference (http://lasi.lmtg.obs-mip.fr/LASI4/home.html), to be held in the classic area where laccoliths were first defined (Gilbert, 1877), the Henry Mountains of Utah (United States).

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