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A review/evaluation of the PhD thesis
Magnetic fabric, magma flow, and tectonic deformation in volcano-plutonic systems
by MSc. Filip Tomek

The thesis consists of an abstract, preface, introduction, 5 essential chapters – actually three published and two submitted papers, four of them with MSc. Filip Tomek as the first author, a summary, supplementary material (copies of published papers) and appendices (mostly AMS data and station locations).

The thesis, as required, includes in the title pages the statement „Herewith, I certify that I have worked on this Ph.D. thesis by myself and that I have properly cited all the relevant literature and other sources of information. However, all essential chapters of thesis are more or less copies of published/submitted papers written in co-authorship and the thesis does not include any statement that would indicate what is the contribution of MSc. Filip Tomek (I believe that most of the stuff) and what is the contribution of his co-authors. This is a formal problem and should be solved by the commission.

The thesis is well organized, written in a concise, logical, straightforward style, well illustrated by high quality figures, with a minimum of formal errors that I will not comment.

The essential five chapters there are:

Chapter 1: Growth of intra-caldera lava domes controlled by various modes of caldera collapse, the Štiavnica volcano–plutonic complex, Western Carpathians,
a manuscript under review in Journal of Volcanology and Geothermal Research

Chapter 2: Magma flow paths and strain patterns in magma chambers growing by floor subsidence: a model based on magnetic fabric study of shallow-level plutons in the Štiavnica volcano–plutonic complex, Western Carpathians,
a paper published in Bulletin of Volcanology (2014) 76: article No. 873

Chapter 3: Volcano–tectonic interactions, crustal strain, and plate kinematics during Late Cretaceous shutdown of the Sierra Nevada magmatic arc, California,
a manuscript under review in Geological Society of America Bulletin

Chapter 4: Simultaneous batholith emplacement, terrane/continent collision, and oroclinal bending in the Blue Mountains Province, North American Cordillera,
a paper published in Tectonics (2015), 34, doi: 10.1002/2015TC003859

Chapter 5: Granitic magma emplacement and deformation during early-orogenic syn-convergent transtension: The Staré Sedlo complex, Bohemian Massif 124
a paper published in Journal of Geodynamics (2015) 87:50–66

There are two unifying aspects of these chapters: 1) application of the AMS studies of magmatic rocks; 2) individual chapters represent different levels of a hypothetical magmatic system in a continental magmatic arc/back arc setting.

As the texts of individual chapters went through or are under a review by highly qualified scientists addressed by the top quality international journals, there is not too much space left for me. As the first chapters devoted to extrusive domes and subvolcanic intrusions of the Štiavnica stratovolcano are from the region I am familiar with, my specific comments concern especially these chapters, introduction and summary. I have no specific comments concerning the remaining three chapters.

Introduction:

Magmatic systems in continental magmatic arcs

This theme is excessively simplified. The systems are treated as one type of systems, ignoring their variability in different geotectonic settings. Specifically, the chosen field areas combine surface, respectively shallow magmatic bodies related to a stratovolcano in the back-arc extension setting, where magmas originate and evolve due to extension-related tectono-thermal reactivation with deeper situated intrusions/plutons of continental margins under compression. These two groups of shallow and deeper magmatic bodies could not represent a one crustal extent magmatic system. It is obvious that the theme needs a more extensive treatment that would include also the problem of emplacement mechanism and its structural control.

Also, it is important to explain, which types of intrusions can be considered as solidified magma chambers. Specifically, the authors take as granted that high-level plutons represent “fossil” magma chambers. While some of the high-level plutons might have fed co-magmatic volcanic eruptions and be considered as shallow magma chambers, it is not the case of the Štiavnica stratovolcano subvolcanic diorite and granodiorite plutons. Contrary, they are themselves products of a deeper lying magmatic chamber that played an important role in their emplacement mechanism.

Internal fabrics in volcanic and plutonic rocks, AMS, What can magmatic fabrics tell us?

No comments, well presented stuff.

Aims and goals of the thesis

They are ambitious and with few minor shortcomings (see bellow) have been reached.

Chapter 1: Growth of intra-caldera lava domes ...

a manuscript under review in Journal of Volcanology and Geothermal Research

The author uses the term *“The Štiavnica volcano-plutonic complex”* that sound like a defined lithostratigraphic unit. However, such the lithostratigraphic unit has not been defined. According to the text it evolved in 3 stages, however, the published evolution of the Štiavnica stratovolcano involves 5 stages (Konečný et al., 1998). The author systematically avoids a use of established lithostratigraphic units, what can create a confusion in correlation with already published papers on structure and evolution of the stratovolcano..

The text mentions a high relief as reason for the exposure of subvolcanic intrusions in the central zone of the stratovolcano. However, it was an uplift of the resurgent horst (1000 – 2000 m) that exposed basement and subvolcanic intrusions (vertical relief of 400 m alone would not allow for that) in the central part of otherwise quite well preserved stratovolcano.

Fig. 1b is not a geologic map – it is an oversimplified structural scheme that does not distinguish the pre- and post-caldera products. A bit more detailed scheme would serve better.

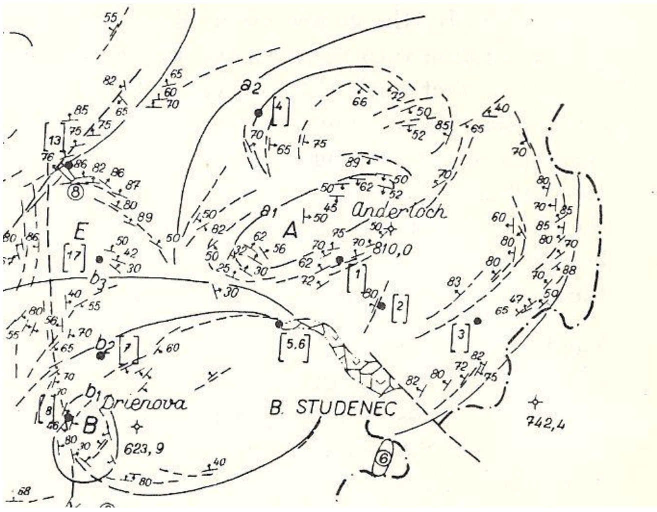
Description of the stratovolcano evolution is not exact enough (if compared with the source text) – the stratovolcano evolved in 5 stages (post-caldera stages should be included as well), a new zircon age for diorite points to its older age (Kohút and Danišík, 2013), granodiorite to quartz-diorite porphyry stocks do not accompany granodiorite – they represent an independent intrusion event (missing in the fig. 2), caldera collapse does not preceded the emplacement of quartz-diorite porphyry sills and dikes – only the youngest and uppermost sills intruded into the lowermost parts of caldera filling, the initial stage of caldera collapse was accompanied only by minor volcanic activity.

Andesite lava domes

Composition is limited to andesites and rare dacites (58 –65 % SiO2), no basaltic andesites.

Dome 1: Owing to a cover of post-caldera andesites the real extent of the dome is unknown. No own field data concerning lithology and structural aspects are presented.

Dome 2: Its present extent is limited by younger faults, its real extent and form is unknown – the statement that the dome is elongated along the caldera fall might be wrong; domains of different petrografic composition at the north and south (Konečný et al., 1998a) point to a possible complex of at least two domes. No own field data concerning lithology and structural aspects presented.



Dome 3: An internal zone of extrusive breccias points to a possible subdivision, at the east the dome passes into a coulée that is not included. In this case there exist a publication by Konečný V. and Dublan L. 1969 (The analysis of cumulodome forms of acid andesite volcanism in the area of Banská Štiavnica, Geologické práce, Správy 48, 5-27) that overlaps spatially with the dome 3 in its southern part and shows a quite different pattern (left) as indicated by the fig. 4 of the thesis.

Generally speaking, the field documentation of objects studied is insufficient and does not make a sound basis for the interpretation of AMS data. Selection of the domes 1 and 2 for the AMS studies was not the best one, as their exposed parts are substantially limited by younger cover (dome 1) or younger faults (dome 2).

Fig. 5 qote: „(a) Porphyritic biotite–pyroxene andesite (dry mineral assemblage), amphibole is completely opacitized, specimen FT75 (Dome 1)“. One has to be careful with naming coarse porphyritic rocks on the basis of single thin sections that are not representative enough due to a random distribution of phenocrysts.

Anisotropy of magnetic susceptibility

Methodology of AMS, magnetic mineralogy supported by thermomagnetic and BSD analyses, AMS data and their presentation – well done parts, no comments.

Discussion

The described proces of opacitization (breakdown of amphibole and biotite due to decompression upon magma ascent is not a sole type of opacitization in relevant rocks. . Another type is represented by subsolidus hematitization due to interaction of minerals with steam – it affects also orthopyroxenes, gives rocks chracteristic pink to reddish color and does not affects minerals in rocks with glassy groundmass.

Dome 1: arguments are logical, conclusions sound with exception of the last statement involving an inclined surface to produce coulees – domes pass into coulées even on a flat bottom – it is a matter of viscosity, volume and rate. According to the fig. 9 stretching close to the caldera fault should have a regular orientation, however, magnetic lineations are oriented randomly. What is the problem?

Dome 2: Due to younger faulting and burial of the eastern part of the dome we do not know the shape of the dome – conclusions are in this case speculative, not really supported by the AMS data alone.

Dome 3: Arguments and conclusions are reasonable, however they can not be considered as well supported by the presented data. I miss confrontation of AMS data with geological aspects and orientation of flow banding.

General implications

As the dome models can not be considered as well established their correlation with a caldera collapse mechanism is rather speculative. The terms „trap-door“, „piston“ and „piecemeal“ collapse are usually applied to whole calderas, not their parts. A change in the style with the time is possible, however, it is not supported by the available data. Collapse of the caldera and the dome growth has to be simultaneous as evacuation of magma from the chamber is the cause of subsidence. Fast collapses are characteristic of explosive calderas – the collapse of the Štiavnica caldera was governed by a slow outflow of viscous lavas that may take with interruptions tens of kiloyears. Also, in the case of the Štiavnica stratovolcano we should consider the caldera collapse as the last stage in a protracting emplacement of magma bodies by the mechanism of the central block subsidence into the differentiated magma chamber that has started already by the emplacement of the granodiorite pluton.

Conclusions

While conclusions concerning dome emplacement can be regarded as probable, the conclusions relating models of dome emplacement to the styles of caldera floor collapse are possible but speculative. One has to also take into account that only 3 of perhaps 20 domes were studied and results need not be representative.

Chapter 2: Magma flow paths and strain patterns …

a paper published in Bulletin of Volcanology (2014) 76: article No. 873

Naturally, in this case the paper went through a rigorous scrutiny of peer reviews and revisions and little is left to be criticized or questioned. However, the reviewers were not familiar with the local geology and thus have left something for me.

The authors take high-level plutons as representing “fossil” magma chambers – see comments concerningthe introduction.

The geologic background, including the fig. 2, does not respect data sources in details, including lithostratigraphic terminology, defined evolutionary stages and precise succession of events. Much more attention could be devoted to the complex of quartz-diorite sills and dykes, as these represent a later stage in the subvolcanic intrusions emplacement and could help to understand emplacement of the granodiorite pluton too.

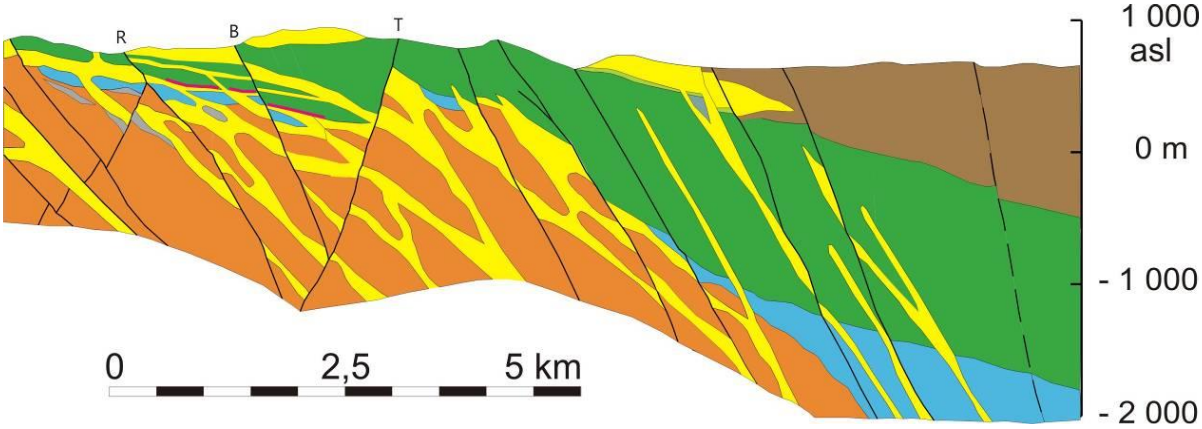
Equally important is to point to a subdivision of the pluton by and tilting of the blocks on the resurgent horst related faults/veins (naturally, tilting has affected also AMS data) and one can think about a correction of measured data.

I miss also information on the extent of the covered parts of the pluton (a figure showing a E-W section would be useful) – the terms W pluton margin, pluton center and SE pluton margin in the fig. 7 are misleading as that figure shows only a small part of the pluton. What is termed as western and southeastern margins are not margins of the pluton but faults limiting surficial exposures. Changes in texture of granodiorite from equigranular poikilitic in internal parts towards slightly porphyritic close to the roof should be mentioned too.

AMS data on granodiorite are interpreted as different close to the roof and farther from the roof. However, the distance of individual stations from the roof is not considered and so the interpretation might be misleading!

There are three features that point to a possible trap door emplacement mechanism of the diorite stock/pluton: E-W elongation along the northern edge of the younger granodiorite pluton, a flat concordant roof at the contact with Triassic sediments at the west, and small remnants of diorite at the roof of the granodiorite pluton.

While it is obvious, that the bell-jar pluton emplacement has to start as a sill and the piecemeal floor subsidence is possible, the style of the next stage quartz-diorite porphyry sills and ring dykes (figure) points to a transitional style between piston and piecemeal styles. The emplacement style of quartz-diorite porphyry should be taken into account in interpretation of the granodiorite pluton emplacement. Fault bounded floor blocks assumed by author with the piecemeal floor subsidence model might be in contradiction with actual stress pattern in the time of granodiorite emplacement (Nemčok et al., 2000).



W-E section at the eastern, covered part of the granodiorite pluton (brown – caldera fill, yellow – quatz-diorite porphyry, red – granodiorite, green – pre-caldera andesites, blue – basement rocks).

The text includes also a very valuable part devoted to models of AMS patterns with different floor subsidence styles.

Generally speaking, better and more dependable interpretations of the AMS data could be reached if available geological and structural data would be used in a greater extent.

The remaining three chapters are excellent scientific treatments of geological, structural and tectonic problems that can be successfully addressed by application of AMS studies of relevant magmatic rocks in context of other geological and structural data. They demonstrate not only the author's ability to apply routinely the AMS analysis including identification of magnetic susceptibility carriers, but also his ability to interpret the results in context of the local and regional geological and structural evolution. He also works with a broad set of up to date relevant references, so the work is devoted to the issues that contribute significantly to understanding of relevant geological processes, like there are the magma emplacement mechanism, tectonic control of magma emplacement and structural evolution of orogenic systems involving magmatic rocks.

The presented thesis is a proof that the adept of the doctoral degree Msc. Filip Tomek is a grown-up scientist, an excellent specialists in the field of AMS studies and their interpretation. Let us take the mentioned minor shortcomings in two chapters devoted to rocks of the Štiavnica stratovolcano as warning, that the interpretation of AMS studies to be dependable and unquestionable requires beside other matters also a very careful confrontation with all available geological and structural data. Othervise the interpretations might be somewhat hypothetical.

Despite the minor shortcoming mentioned above I am pleased to conclude that the PhD. thesis by MSc. Filip Tomek is an excellent set of works that certainly merit the award of the doctoral degree.

In Bratislava, The August 15th, 2015