



## Posudek disertační práce

Uchazeč Ing. Michael Somr

Název disertační práce Analysis of Fracturing Processes Preceding Caldera Collapse

Studijní obor Fyzikální a materiálové inženýrství

Školitel Prof. Ing. Petr Kabele, Ph.D.

Oponent Prof. Ing. Michal Šejnoha, Ph.D., DSc.

e-mail sejnom@fsv.cvut.cz

### Aktuálnost tématu disertační práce

komentář: Scientific relevance of the submitted work

The present thesis is focused on explaining the potential cause of formation calderas due to the rupture of the magma chamber roof. Although relatively rare such an event may have an enormous environmental and social impact. As there still remain many open questions concerning geometrical aspects, loading conditions associated primarily with chamber pressure evolution, and consequently evolution of localized failure zones triggering the onset of caldera formation, the selected research topic is doubtless up to date and certainly deserves attention.

vynikající     nadprůměrný     průměrný     podprůměrný     slabý

### Splnění cílů disertační práce

komentář: Goals of the work and their achievements

The main research objectives, arising from a comprehensive literature survey given in Chapter 1, are clearly stated in Chapter 2. Given the geometrical variability of magma chamber as well as a relatively large number of potential loading scenarios, the author managed to select the most relevant once so that all goals were in main part successfully achieved. This is clear from the overall summary provided in Chapter 6 and in particular from Chapter 5 presenting a thorough discussion on the results on extensive program of numerical simulations.

vynikající     nadprůměrný     průměrný     podprůměrný     slabý

### Metody a postupy řešení

komentář: Treatment of the topic - methodical and conceptual approach

The methodical and conceptual approach is described in Chapter 3. It addresses all important topics associated with the finite element modeling of nonlinear problems. In my opinion, however, this chapter is too brief and deserves more attention. Some issues should be explained in more details. These include:

1. Formulation of the viscous model. Referring the reader to ADINA manual is not sufficient to make the Ph.D. thesis comprehensive. For example, it is not clear, how the time dependent problem with velocity degrees of freedom enters the general static analysis. Some grounds regarding the formulation of the transition element could also be provided.
2. How the loading was specified? Does the distribution of pressure in Figure 3.2 represent the course of the prescribed load? There are no units specified on both axes. Where this figure

comes from?

3. The last paragraph on page 21 is a bit unclear. It would be better to show the loading and boundary condition graphically. What does the author mean by the prescribed potential flux to represent the uniform change of pressure in the magma chamber?

4. If the flux is prescribed over the boundary of the cavity, what is then the role of magma? Or am I missing something?

Please address these points during presentation.

vynikající    nadprůměrný    průměrný    podprůměrný    slabý

### Výsledky disertace - konkrétní přínosy disertanta

komentář: Thesis results - author's specific contribution

The principal outcomes of the theses can be extracted from Chapters 3-6. On the one part it is the conceptual approach adopted to address the examined problem, which bases on the application of advanced numerical tools and suitable constitutive models. This appears rather unique in the field of geological engineering and well advances the current state of the art. However, a notable achievement of the present study, significantly contributing to this field, is an extensive numerical study carried out in the course of this thesis and in particular the subsequent discussion of the available results provided in Section 5. The selected presentation format I found very interesting, clear, and particularly appealing to research community not familiar with numerical simulation of damage. Nevertheless, I still believe it would be interesting to accompany individual figures in Chapter 5 with plots showing a gradual evolution of plastic equivalent strain, e.g. at locations associated with the onset of damage, as a function of pressure increase/decrease (overpressure/underpressure) during individual loading stages. Perhaps an example of one particular case of inflation-deflation loading process accompanied by the loading diagram (pressure vs. pseudo-time) could be provided during the thesis defense for illustration.

vynikající    nadprůměrný    průměrný    podprůměrný    slabý

### Význam pro praxi a pro rozvoj vědního oboru

komentář: Extent of new knowledge and contribution to the practice

The thesis certainly shed light on a number of specific issues concerning the modeling of caldera formation. Although well known in the field of numerical simulation of nonlinear material response, the tools adopted seem unique in the study of the present task and certainly open way to even more advanced approaches taking into account thermal effects, time aspect of complex geological processes, etc. As I am not an expert in this field I suggest the author to give, during the thesis defense, his own opinion on most probable cause of caldera formation, given the collected evidence of these events, which I was not able to clearly identify from the final conclusion remarks. The answer to, if already available, would certainly mean a major contribution to this subject.

vynikající    nadprůměrný    průměrný    podprůměrný    slabý

### Formální úprava disertační práce a její jazyková úroveň

komentář: Organization of the work and overall comprehensiveness

The thesis are written in good English with only few grammatical errors. It is well structured and easy to follow. The only source of criticism, as already mentioned, offers Chapter 3, which in my opinion is too brief lacking more detailed explanation of a number of important aspects of numerical simulations. But even this drawback does not reduce significantly the thesis high standard.

vynikající    nadprůměrný    průměrný    podprůměrný    slabý

## Připomínky

Comments:

Apart from comments raised already in the review section "Treatment of the topic" the following questions might be addressed in more details:

1. The author adopted an elastic perfectly plastic constitutive model to address both the onset and subsequent advance of failure. To then end, only one set of parameters, taken from literature, was used. Has the author performed some sort of sensitivity study on the influence of individual data on the prediction of failure evolution? The dilation angle in particular is known to play a significant role in this regard.
2. For intact or highly jointed rocks, the Hoek-Brown model appears more suitable in comparison to Mohr-Coulomb model. Since HB model is typically not available in the commercial codes, it is often substituted with MC model with parameters derived on the basis of parameters more suitable for rock classification, e.g. the Geological Strength Index (GSI). Has the author tried to compare the adopted values for cohesion and the angle of internal friction with those typically used for the nonlinear HB surface? I understand, this would require some sort of geological survey at the particular site examined, which might not be available.
3. Was there any particular reason to exclude the hoop strain from the definition of equivalent strain in Eq. (4.2)? In MC model all stress components enter the formulation of the second invariant of deviatoric stress linked to the corresponding equivalent deviatoric strain, which in turn accommodates all three normal strain components. Please make a comment on that.
4. It seems possible to relate the difference in damage (failure) scenario for shallow and deep seated chambers to those obtained for shallow and deep seated tunnels, where deflation can be linked to an excavation step, and were the arching effect for deep seated tunnels reducing the load due to overburden is well known. What is the author opinion? In this regard, has the author tried to examine the influence of magma but assuming, e.g. only the cavity loaded by internal pressure?
5. What time scale would we talk about, if the thermal effects were taken into account through the coupled transient analysis? Is the time variation of temperature in magma available?

## Závěrečné zhodnocení disertace

Final statement:

Based on the submitted review, consisting of an assessment of the scientific relevance, fulfillment of the goals of the work, the quality of treatment of the topic and the extent of new knowledge, it is concluded that this work meets very high quality standards.

As it complies with the requirements for a Ph.D. work, I recommend the thesis for further defense and if successful to appoint Ing. Michael Somr the title

doctor (Ph.D.)

Doporučuji po úspěšné obhajobě disertační práce udělení titulu Ph.D.  ano  ne

Datum: 16. 5. 2019

Podpis oponenta: 