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Discussions

Interactive comment on "Up the down escalator: the exhumation of (ultra)-high pressure terranes during on-going subduction" *by* C. J. Warren

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It is certainly good idea to write a review on exhumation mechanisms for continental UHP complexes. Indeed, taken experience of the Author in numerical modeling, she could have done much better job with this paper. The review contains several wrong concepts (including the title), the numerical modeling literature is not up to date and several important topics (such as e.g. tectonic overpressure, discrepancies in peak temperature between natural and modeled P-T paths) and exhumation concepts (e.g. eduction, slab breakoff, crustal-scale stacking) remained unaddressed. I have an impression that the Author's view on the problem is too much affected by results of 2D numerical experiments with prescribed plate velocity, which typically shows UHP exhumation by flow in various subduction channels during ongoing subduction. In nature,

motion of plates changes with time and (according to both numerical and geological-petrological literature) several other exhumation processes, which do not require simultaneous subduction (e.g., crustal-scale stacking, slab breakoff, eduction, delamination etc.), can be viable/dominant in nature. Consequently, significance of channel flow is strongly overstated in this paper which meant to be a comprehensive review. My major concerns with the present MS are given below

1. Title "Up the down escalator: the exhumation of (ultra)-high pressure terranes during on-going subduction" is catchy but misleading. Exhumations by eduction (Andersen et al., 1991; Duretz et al., 2011), for example, implies reverse motion of the slab. Buoyant exhumation that post-date slab breakoff also post-date subduction. Better title would be, for example "Exhumation of continental UHP terrains: concepts and models." The same also concerns main focus of the paper starting from Introduction ". . . exhumation proceeded during on-going subduction: "up the down escalator " . . ."

2. Literature is not comprehensive and is not up to date. Except few self-citations, recent numerical modeling literature on UHP PT-paths and exhumation is missing, which is very surprising for the review paper. Here are some: Gerya et al., 2008 ; Burov and Yamato, 2008; Yamato et al., 2008; Faccenda et al., 2008, 2009; Duretz et al., 2011; Li and Gerya 2009; Li et al., 2009, 2010; Van Hunen and Allen, 2011, etc. The Author yet needs to do serious literature work.

3. Abstract contains misleading statements, for example "In order for buoyant continental crust to subduct, it must remain attached to a stronger and denser substrate, but in order to exhume, it must detach (and therefore at least locally weaken) and be initially buoyant. " Same wrong concept as in the title – detachment of the crust is not required by eduction process of a coherent slab (Andersen et al., 1991; Duretz et al., 2011). Another wrong concept concerns buoyancy - exhumation by forced circulation in a confined subduction channel surrounded by rigid plates does not depend on buoyancy of the channel rocks and is driven by mass conservation (corner flow, cavity driven flow).

SED
4, C271–C277, 2012

4. Introduction is too short and fragmentary and again introduces wrong concepts of "up the down escalator " and significance of buoyancy within the subduction channel.

5. Section 2 "Types of exhumation processes" again looks like confining variability of exhumation mechanisms to one special case of an isoviscous channel flow where buoyancy of subducted rocks should play a role (Figs. 1a, 2, such channel is open from the bottom and directly contact with low-viscosity mantle to allow for the balance between the traction an the buoyancy). Introducing concept of exhumation number does not seems to be useful: it is valid for the idealized isoviscous channel but is rather useless for more realistic rheological cases where effective viscosity is highly variable in time and space (Chemenda et al., 1995; Gerya and Stoeckhert, 2006; Li and Gerya, 2009; Yamato et al., 2008, Duretz et al., 2011 etc.).

6. Section 3. Strain weakening. "In these models, weakening is applied to the bulk crust, which is effectively treated as being homogeneous. At present it is still unclear whether strain weakening can weaken a terrane enough to allow it to flow on a regional scale, as suggested by numerical models (Gerya et al., 2002; Warren et al., 2008a) or to exhume only as a rigid block with weak boundaries, as suggested by field studies (e.g. Labrousse et al., 2002). A combination of these two end-members probably operates at all scales." The author should really study recent numerical modeling literature where influence of non-linear rheology with localization phenomena on UHP exhumation processes is investigated (Gerya and Stoeckhert, 2006; Gerya et al., 2008; Yamato et al., 2008; Li and Gerya, 2009).

7. Section 4. Melt weakening. Several more numerical modeling papers discussed effects of slab-derived diapirs and melting on UHP exhumation (Gerya and Yuen, 2003; Gerya et al., 2004, 2008, Gerya and Stoeckhert, 2006; Faccenda et al., 2008, 2009; Castro and Gerya, 2008)

8. Section 5. "Numerical models of the transition from oceanic subduction to continental collision". Only two papers are referred (Burov et al., 2001; Warren et al., 2008b)

SED

4, C271–C277, 2012

first of which used evolved continental subduction as the initial condition. There are many more papers on modeling of this process: Gerya et al., 2008 ; Faccenda et al., 2008, 2009; Duretz et al., 2011; Li and Gerya 2009; Li et al., 2010; Van Hunen and Allen, 2011.

9. Section 5.1 Plunger expulsion. ". For a system subducting material of heterogeneous strength, the plunger model predicts episodic exhumation during the subduction of the stronger units." Episodic exhumation can also happen in case of homogeneous subducted crust as suggested for e.g. Sulu terrain (Li and Gerya, 2009).

10. Section 5.2. Driven cavity flow. "Driven cavity flow will exhume material which is neutrally or only weakly positively buoyant, but this mechanism does not, at least in the models, produce extremely rapid exhumation rates (Warren et al., 2008b)". Completely wrong statement. Driven cavity flow will exhume homogeneous material of any density since the flow is confined between rigid walls and is driven by conservation of mass. Obvious example is steering of water in a glass - density of the glass does not play a role as soon as it is rigid. High exhumation rate can be indeed produced by rheological focusing in the channel (Gerya and Stoeckhert, 2006).

11. Section 6.1 Slab rollback. "The (transient) insertion of thicker continental material into the subduction zone may trigger a decrease in the subduction rate, hence allowing the subducting slab to steepen and roll back (Brun and Faccenna, 2008). The ensuing trench retreat would therefore create space for detached subducted material to exhume." I do not think the delamination process is well described here. In fact, this process is mainly controlled by the coupling at the subducting continental moho. Dynamics of delamination process and related exhumation of UHP rocks in core complexes is modeled by Faccenda et al. (2009) and Gray and Pysklywek (2012).

12. Section 6.2 Upper plate retreat. As follows from fig 6 difference between two types of retreat is rather rheological – exhuming buoyant material goes into the weakest point, where extension is localized.

SED
4, C271–C277, 2012

13. Section 6.3 Transtension. It is surprising that there is no mention of slab breakoff and eduction in relation to the Western Gneiss Region (e.g. Andersen et al., 1991; Duretz et al., 2011).Generally, slab breakoff and eduction, which are critical processes for the continental collision and exhumation of UHP rocks, are not discussed at all.

14. No discussion is present on (1) possible influences of tectonic overpressure on UHP rock P-T paths and (2) descrepancie between peak metamorphic temperatures for nature and models – these are very interesting and controversial topics with many recent literature involved (Manktellow, 1995, 2008; Petrini and Podladchikov, 2000; Yamato et al., 2008; Babeyko and Sobolev, 2008; Burov and Yamato, 2008; Gerya et al., 2008; Vrijmoed et al., 2009; Li et al., 2010).

In conclusion, although I like the idea of writing such paper, present manuscript needs serious reworking and re-review.

Taras Gerya, Zurich, 01.07.2012

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