Numerical Modeling of Shock Wave Propagation in Iron and Troilite Assemblages in Ordinary Chondrites

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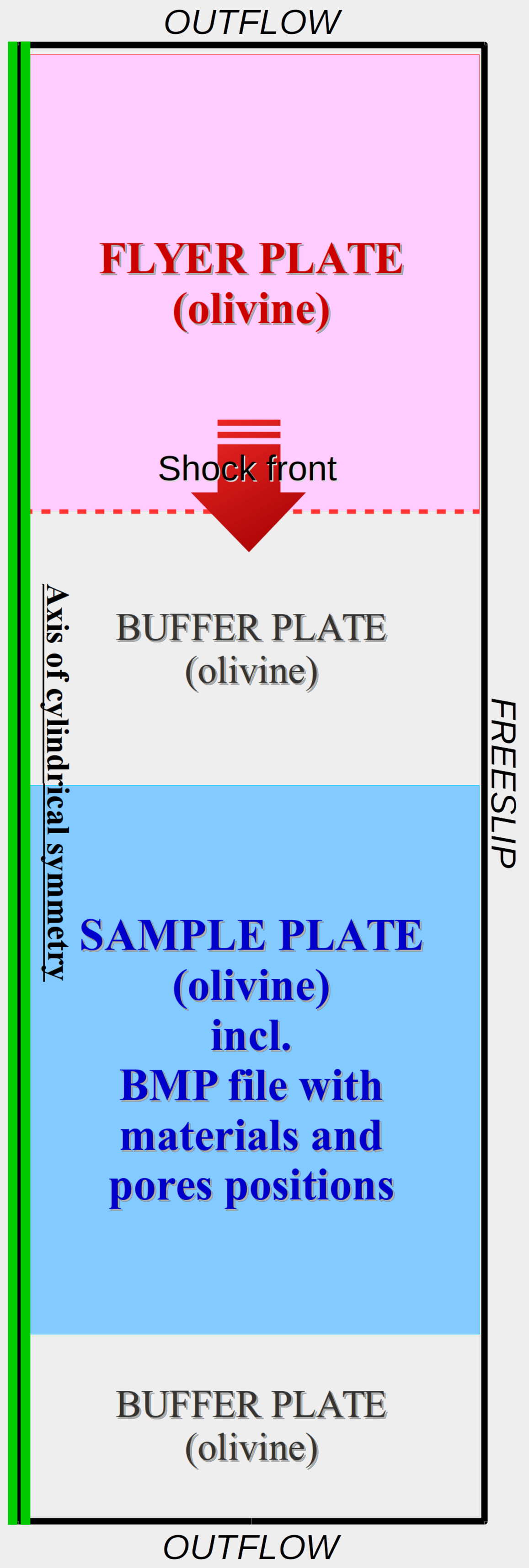

Fig. 1. Model concept

INTRODUCTION

We present models of shock compression in various configurations of metal and iron sulfide mixtures, and resulting heating and melting [1]. This work takes place in the understanding of shock-darkening in ordinary chondrites, in other words, the melting of iron sulfides and metals into a network of darkening veins [2].

METHODS

Using the shock physics code iSALE [3], we implemented a mesoscale setup [4] (Fig. 1) in which we embedded grains of troilite, iron, and albite phases, in olivine. We assessed peak shock pressures, post-shock temperatures and melt fractions for each phase, at 45 GPa of shock pressure in 6% porous olivine. In total, we carried 26 models with configurations of iron, troilite, albite phases, and pores.

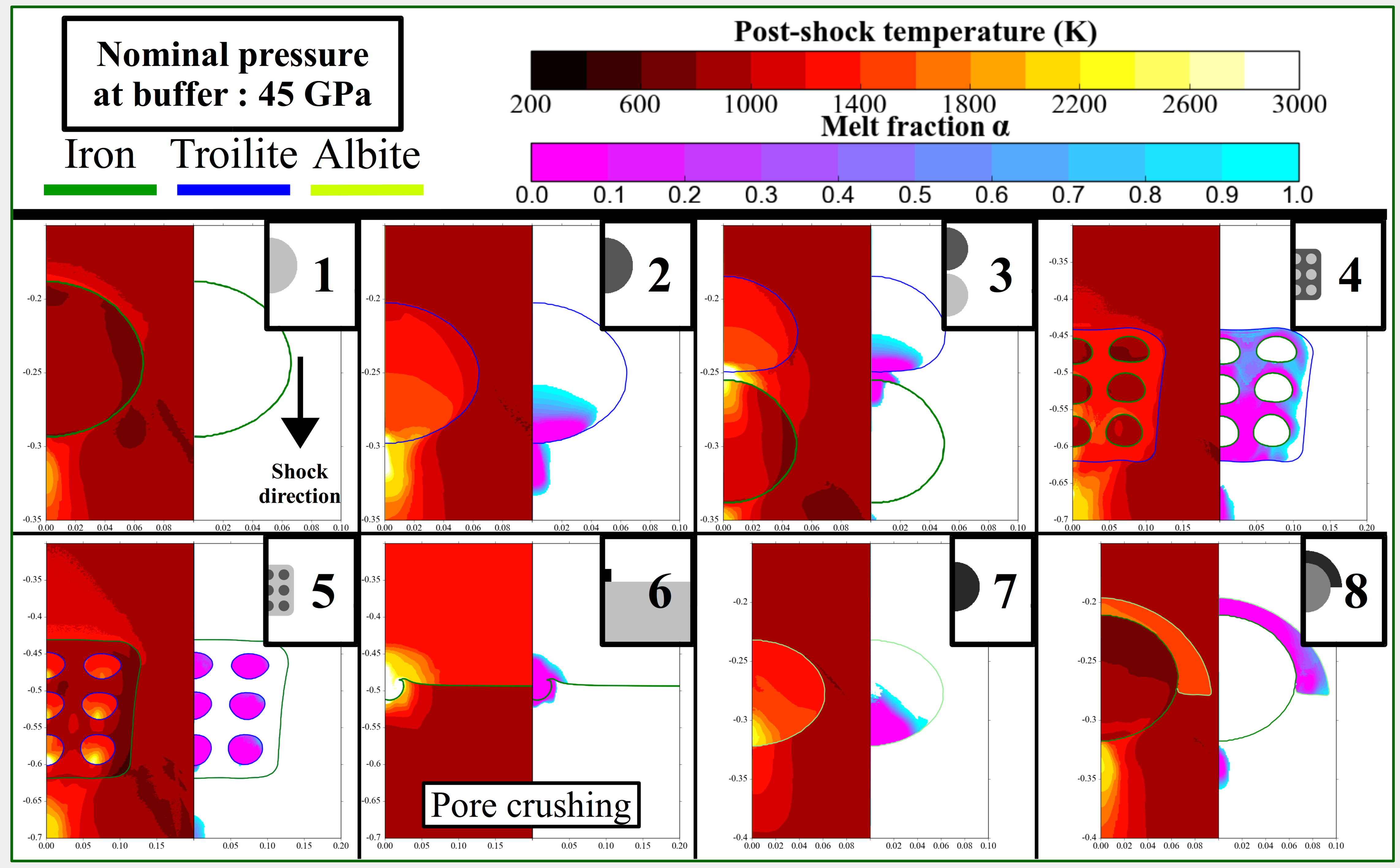

Fig. 2. Conpilation of post-shock temperature and melt fraction (integrating heat of fusion) panels of chosen models. The panels are in a compressed state and original sample plates are shown in the corner of each model. Strong heating of troilite and albite phases is recorded in addition to localized heating in olivine by pressure concentration or pressure reflection effects.

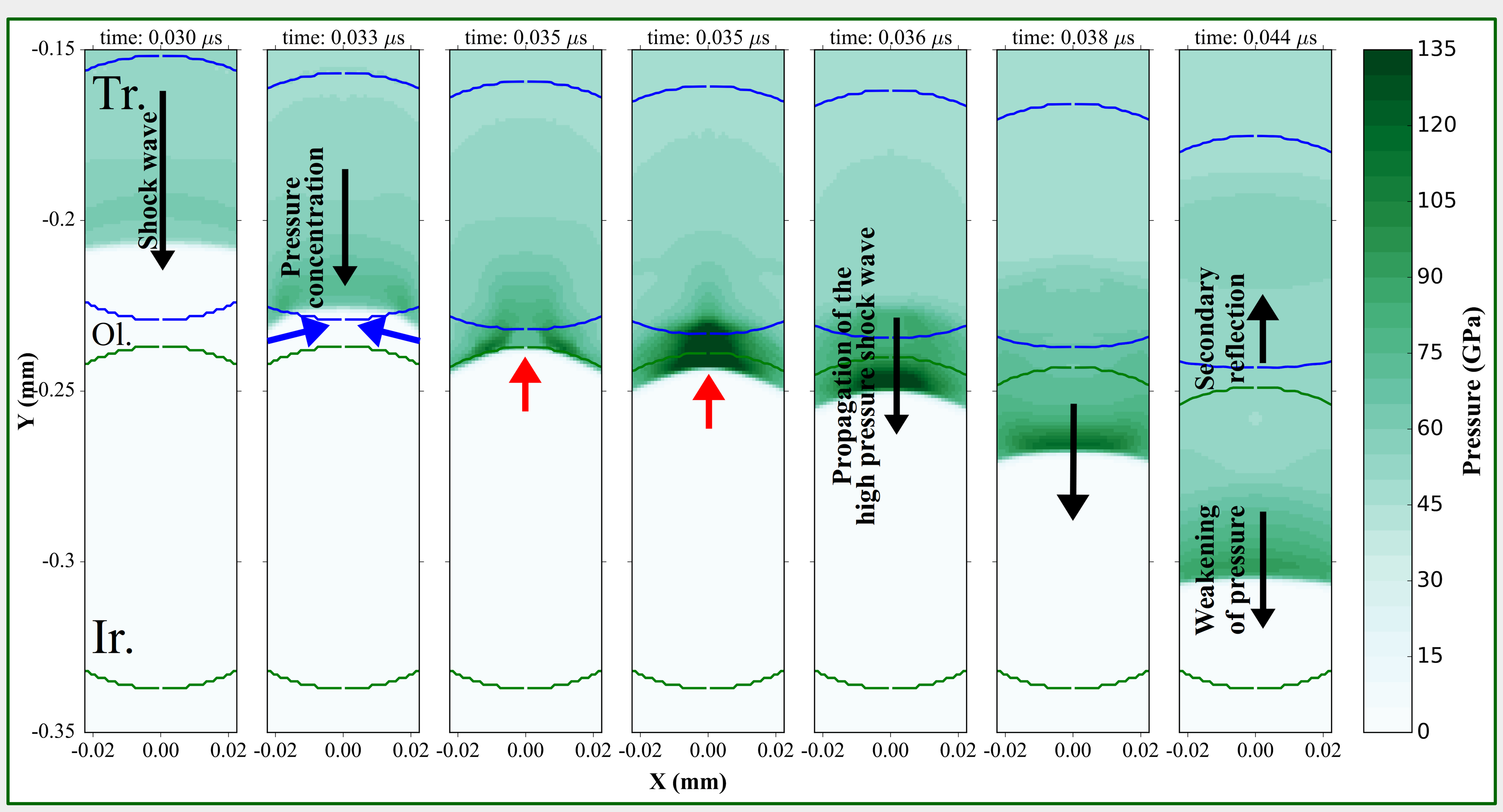

Fig. 3. Propagation of the shock wave in model no. 3 from Fig. 1. The blue arrows depict the shock wave (due to a velocity contrast), on both sides of the troilite grain, that will collide in the region marked by the red arrows.

RESULTS

Results in term of post-shock temperature and melt fraction (see 8 of the 26 models in Fig. 2) are shortly:

1) Melting of troilite in all models with melt fraction between 0.14 and 0.97.
2) Melting of olivine due to strongly localized shock pressures.
3) Limited melting of iron despite eutectic properties in several models.
4) Contrast of temperatures between iron and troilite (~546 K), and albite (~727 K).

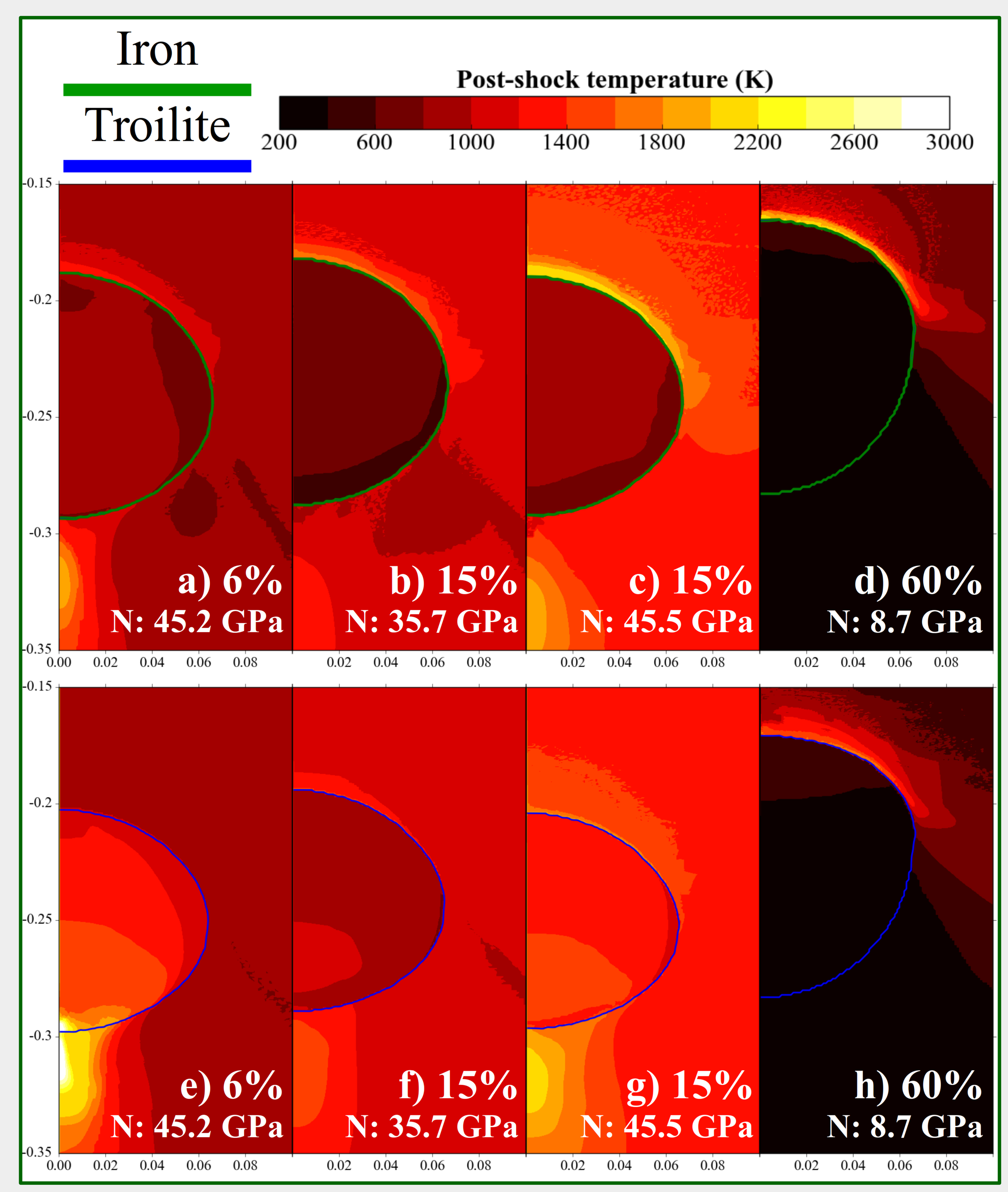

Fig. 4. Effect of olivine porosity (%) on the (N, nominal) pressure, without modifying the flyer plate velocity (panels a-b, d-f, h), on heating of olivine and iron/troilite phases. The c) and g) panels result from a higher flyer plate velocity in order to reach the same nominal pressure as in panels a) and e)

DISCUSSION & CONCLUSIONS

1) Heating strongly dependent on pressure effects (Fig. 3).
2) Melting by pore crushing in both iron and olivine (Fig. 2, panel 6)
3) Heat diffusion likely important between phases which display strong contrast of temperature.
4) Porosity in olivine matrix → heating source or sink toward iron or troilite (Fig. 4).
5) Iron sulfides are the dominant phase over metals in shock-darkened ordinary chondrites [5].

[1] Moreau et al. (2018) submitted, [2] Kohout *et al.* (2014), [3] Wünnemann *et al.* (2006), [4] Davison et al. (2016), [5] Stöffler *et al.* (1991)

Acknowledgements

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