

## Reply to A.G. Milnes

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In his discussion A.G. Milnes criticizes mainly two aspects of our study on isogradic surfaces in the Simplon area:

1. *Degree of precision of the data.* In the tables, maps and profiles of our paper we presented well localized data on mineral parageneses. We do not overestimate the single facts and are fully aware of the limitations of the data and of the challenge of transitional zones. The reader and future explorer can himself evaluate the reliability of the boundaries drawn. We have not been satisfied with merely shading mineral zones, as was done by the pioneers of “index minerals” and “isograds” in Scotland.

We are impressed by the joint evidence for steep isogradic surfaces in the section of the Simplon tunnel. Other explorers have performed more field work in this area than we did, but they have not discussed this petrological problem. Our paper which correlates data of tunnel and of surface samples shall serve as an incentive to coming geologists. Such studies are never complete and can never boast of precision, though their results are more reliable than many tectonic postulates.

The problems of metamorphic plagioclase series are complicated. Recently regular crystallographic intergrowths of andesine and labradorite has been discovered in marbles of the Antigorio-Ticino region. The validity of the criterion “maximum anorthite content” in given mineral assemblages remains untouched.

2. *Interpretation.* The second objection of A.G. Milnes concerns the interpretation of steeply dipping isogradic surfaces which are often discordant to compositional layering. Our model of a thermal dome is of minor importance; fundamental is the following difference:

Like most petrologists working at present in the Alps, we argue that the metamorphic recrystallization accompanied and outlasted the last compressive Tertiary folding, and that the mineral parageneses observed were essentially produced by this syn- to postkinematic crystallization. We are well aware of the polyphase character of Alpine orogenesis and of the changing thermal history, but we do not know of relict assemblages of lower grade, related to the formation of the overthrust nappes, or to stages prior to the isoclinal Wandfluhhorn fold-complex. Petrofabric studies and especially the analysis of the relations between crystallization and deformation are essential for this discussion.

A.G. Milnes on the other hand arrives at a somewhat different conclusion on the ground of structural and textural evidence. He believes that paleo-isotherms

suffered large-scale disturbance by tectonic movements during the metamorphism and that the present distribution of mineral zones is the cumulative endproduct of transient thermal configurations. If this should be true, we wonder why the pattern of mineral zones is so surprisingly regular and simple in the Central Alps, while the large-scale structures are so tremendously complicated? Furthermore, we do not agree with certain aspects of Figure 1 of Milnes, in particular, the curved isogradic surface An<sub>20</sub> in the northern part of the Simplon section. If correct, it would imply that most of the Berisal Complex in the region of the Simplon tunnel were within the albite zone. This is contrary to our Figs. 2a and 3 and to the data presented by Wenk and Keller (1969, p. 179–180 and Table 1), who reported oligoclase and two plagioclase assemblages corresponding to the peristerite gap in amphibolites from this Complex. It has long been known that mineral assemblages in such pre-Alpine rocks as the Berisal Complex faithfully record the overprint of the Alpine metamorphism.

### Reference

- Wenk, E., Keller, F.: Isograde in Amphibolitserien der Zentralalpen. Schweiz. Mineral. Petrog. Mitt. **49**, 139–152 (1969)

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