diese Schwankungen überlagern. In Wechselwirkung mit dem Gestein, das vom Wasser durchflossen wird, ergeben sich daraus unterschiedliche Entwicklungspfade von den quantitativen und qualitativen Inputbedingungen (z.B. Grundwasserneubildung, hydrochemische und isotopische Zusammensetzung) ausgehend zu den quantitativen und qualitativen Outputbedingungen (z.B. Quellschüttungen, Grundwasserstände, hydrochemische und isotopische Zusammensetzung). Das Verständnis dieser Entwicklungspfade auf der Untergrundpassage ermöglicht z.B. Aussagen hinsichtlich Speichereigenschaften der Gesteine, Verweilzeiten der Wässer und deren Einzugsgebiete.

Die Erfassung der statischen und dynamischen Systemkomponenten erfolgt durch die klassischen Methoden der Geologie, Hydrogeologie und Hydrologie sowie von verwandten Fachdisziplinen (u.a. Geophysik, Bodenkunde, Hydrochemie und Geochemie, Isotopenphysik) und ergeben in ihrer Wechselwirkung das „hydrogeologische Konzeptmodell" – als konzeptionelle Vorstellung des Hydrogeologen hinsichtlich des hydrogeologischen Systems. Aus dem „hydrogeologischen Konzeptmodell" werden Eingangsdaten für die numerische Strömungsmodellierung abgeleitet.

Interpreting Metamorphic Field Gradients

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We discuss possible relationships between (i) metamorphic grade, (ii) timing of the metamorphic peak and (iii) magnitude of the thermal perturbation that can be mapped when investigating metamorphic field gradients. We show how these relationships may be used to infer heat sources of metamorphism. For this, we (re-)define a number of used and misused terms. *Metamorphic field* gradient is defined as the pressure or temperature gradient measured normal to metamorphic isograds as mapped in the field. *Metamorphic geotherm* is defined as the transient relationship between depth and temperature in the crust during metamorphism. *Piezothermal* and *piezobaric arrays* are defined as the lines that connect the metamorphic temperature and pressure peaks in a vertical column through depth and time, respectively. To interpret field relationships, we emphasize the importance of two further relationships that may be mapped in the field: 1. The *temporal* relationships between rocks of different grade, which describe if higher grade metamorphic rocks experience metamorphism earlier or later than lower grade rocks. Fig. 1a shows that these are qualitatively different between different metamorphic processes. In the Austroalpine the temporal characteristics of metamorphism during Eoalpine times are consistent with conductive heat sources. 2. The *thermal perturbation characteristics* describe whether low grade rocks are more or less thermally perturbed than high grade rocks (Fig. 1b). In the Austroalpine during Eoalpine times, the thermal perturbation characteristics are *inconsistent* with conductive heat sources. Fig. 2 shows that both timing relationships and thermal perturbation relationships may also change depending on the exhumation process by extension or by erosion. We conclude that metamorphic field gradients bear abundant information on the nature of metamorphic heat sources that is rarely used.

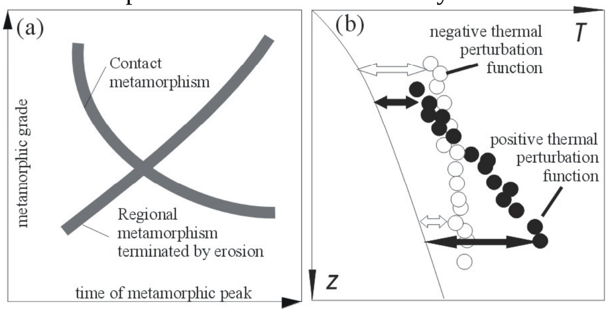

***Fig. 1**. (a) Relationships between metamorphic grade and timing of peak metamorphism during contact and regional metamorphism. (b) Two different possible relationships between metamorphic grade and departure from stable thermal conditions.*

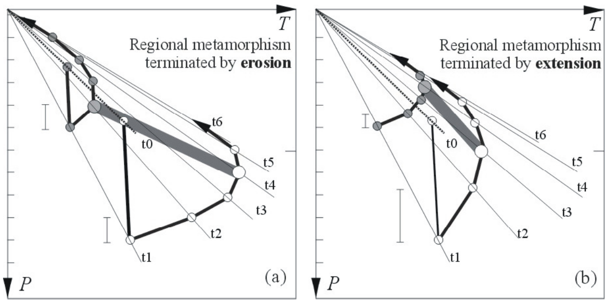

***Fig. 2.** Piezothermal array (thick shaded bar) during (a) erosion terminated regional metamorphism and (b) during extension terminated regional metamorphism. Note that both the timing relationships (Fig. 1a) and the thermal perturbation relationships (Fig. 1b) are different between (a) and (b).*