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TOWARDS A GLACIAL-INTERGLACIAL SEQUENCE CONCEPT FOR MOUNTAIN RANGES, IN COMPARISON WITH GLACIO-EUSTATIC MARINE SEQUENCES

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Compared to detailed and variegated concepts for the development of glacio-eustatically controlled, marginal-marine sequences, no such a concept for the development of comparable successions on land exists. Perplexing this is, since glacio-eustatic sequence development, with its strong forcing by marked and rapid changes in both climate and sea-level, can be expected to be distinct and, to some extent, correlative from sea to land. We present an approach towards an integrated concept for the physical stratigraphic development of glacial to interglacial successions within mountains, and their possible correlation with and relation to contemporaneous marine sequences. Our approach is in part based on (generalized) patterns of deposition during the last glacial-interglacial cycle in the Eastern and Southern Alps (e. g. Van Husen, 1983 a,b; 1997, 1999; Patzelt & Resch, 1986; Patzelt, 1987; Poscher, 1993; and many others) and in part on own observations on the development of Quaternary alluvial fan and talus successions.

During climatic deterioration and buildup of glaciation, large volumes of coarse-grained sediment are produced by increased physical erosion of rocky slopes, and are transferred to alluvial fans, fan deltas and proglacial outwash. How much of these sediments is preserved depends on the local erosive potential of the overriding glacier. During glacial highstand, except accumulation of subglacial deposits, most of the sediment is transferred to proglacial outwash; hence, rates of deposition tend to be highest in the topographically lowest position, in the immediate foreland of glaciers. Interstadial phases may give rise to extremely high rates of accumulation of glaciolacustrine to glaciofluvial deposits, and of other paraglacial deposits, such as alluvial fans. At the same time, towards the foreland, erosive incision prevails. Again, how much of the interstadial deposits is preserved depends on erosion during the subsequent glacial advance.

Upon deglaciation, large volumes of paraglacial deposits (e. g. reworked moraines, sandur, kames) may be trapped by filling of valley stretches overdeepened by glacial erosion. In addition, ice-marginal lakes may form and provide local base-levels for accumulation of fine- and coarse-grained alluvium. In the foreland, fluvial incision prevails. Along the flanks of main tributary valleys and of side valleys, persistent accumulation of alluvial fans and/or of talus slopes starts. In at least some cases, aggraded alluvial fans provide the foundation for the buildup of high talus slopes that prograde over and downlap the proximal portions of the fans. Upon prolonged warm climate and hillslope stabilization by vegetation, the rate of talus production strongly decreases. As a result, a linear-erosive regime is established characterized by fluvial incision, fanhead trenching and, on talus slopes, by incision of chutes. Finally, during stable interglacial conditions, a by-pass regime prevails, with minor and local fluctuations of deposition and erosion; these fluctuations at least in some cases most probably are associated with minor changes of climate.

In the sea, according to the interpretation elaborated by Posamentier & Vail (1988) (for siliciclastic shelves well-supplied by sediment, and situated on a mature passive margin), the phase of glacial buildup corresponds to sea-level lowering, fluvial erosion on the shelf (type I sequence), and to formation of the basin-floor fan and the slope fan. Deposition of the lowstand prograding wedge has been interpreted to proceed under slowly rising, but still low sea-level (Posamentier & Vail, 1988). The corresponding change in glaciation remains less clear. With respect to the marked changes of ice volume from stadials to interstadials in the

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Würmian, it remains open to question inasmuch such fluctuations may cause sea-level changes of global extent large enough to be recorded in marginal-marine sequences. Whereas the phase of deglaciation would correspond to deposition of the transgressive systems tract, stable interglacial conditions correlate with the highstand systems tract (Posamentier & Vail, 1988).

Comparing the two concepts of sequence development, in the marginal-marine sequences, incision of fluvial valleys and of marine canyons is mainly confined to sea-level lowering and early lowstand. During formation of the lowstand wedge, and of the transgressive and highstand systems tract, deposition persists. On the shelf, processes acting over large areas (e. g. tides and other currents, waves) effectively disperse the sediment. For the paralic to neritic part of marine sequences, base-level is closely associated with sea-level, and can be approximated as a low-dipping plane of comparatively simple shape.

In "mountain-valley sequences", by contrast, linear erosion prevails wherever the mean capacity of aqueous sediment transfer is higher than mean sediment load, or than mean sediment production. This can be the case during each of the described stages, albeit at different locations and controlled by different local base-levels. During formation of mountain-valley sequences the altitude, extend and duration of local base-level surfaces strongly fluctuates. For each order of drainage system, its local base-level is provided by the debouch of its highest-order stream into the stream of successive order. Although, for an entire mountain range, the "ultimate" base-level is provided by sea-level, in practice, geomorphic equilibrium with respect to sea-level will need very long to approach. Knickpoints in valley/river profiles and lakes render mountain-valley sequences not an approximation to a single base-level surface of simple shape, but to local base-levels that are laterally separated by areas off base-level.

Marine sequences are just a facet in the entire spectrum of possible styles of sequence development. Neither lateral continuity and extent, nor a peculiar depositional environment in the sea or on land, nor its potential internal complexity or thickness preclude an unconformity-bounded unit to be a depositional sequence, as long as it consists of genetically related strata.

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