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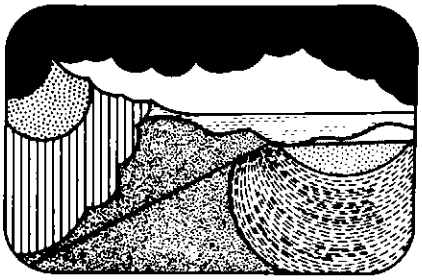

Molasse – Alpine and Columbian

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Summary
Late-orogenic sediments deposited alongside growing mountain belts reflect the rise and cooling of crystalline complexes within the core zone of the orogens. The nature of these molasse deposits is strongly influenced by structures adjacent to the sedimentary basins. Despite differences in scale and paleoclimate the molasse of the Alps and that of the Columbian Orogen show remarkable similarities.

Introduction
One of the principal manifestations of mountain building is concomitant erosion of the newly elevated terrane by synorogenic river systems. In the initial stages of deformation, only small segments of the earth's crust are elevated above sea level and the eroded debris reaches the adjacent marine troughs via vigorous but short streams. At the edges of the troughs much of the material is rapidly dispersed by slumping, debris flows, fluidization and turbidity currents into deeper parts of the marine basins. The resulting synorogenic deposits are monotonous shale-sandstone sequences generally referred to as 'flysch' (Hsu, 1970). During progressive uplift of the orogenic belt ever wider areas are elevated above sea level and deltaic complexes prograde over marine basins. Clastic sediments are laid down on alluvial and delta plains and eventually the basins adjacent to the orogen are filled completely by coarse non-marine sediments. These late-orogenic shallow-marine and non-marine clastics in linear troughs adjacent to rising mountain chains are generally known as 'molasse' (Van Houten, 1973).

In many orogenic belts the molasse overlies flysch or other marine sedimentary sequences, and generally comprises the youngest sedimentary strata of these belts. Well known examples are the type Molasse of the Alps (Studer, 1825; Heim, 1919; Füchtbauer, 1967), the molasse of the Proterozoic Coronation Geosyncline (Hoffman *et al.*, 1970), the Silurian – Permian molasse of the Appalachian Orogen (Potter and Pettijohn, 1963), the Permian – Triassic molasse of the Urals (Mazarovich, 1972), the Cenozoic molasse of the Andes (Van Houten and Travis, 1968), and the Upper Miocene – Recent molasse of the Himalaya – Zagros belt (Gansser, 1964; Stöcklin, 1968). Recent work in the Columbian Orogen of the Canadian Cordillera has shown that the predominantly non-marine Upper Jurassic – Oligocene clastic wedge of the foreland and successor basins shows many characteristics of known molasse basins (Price and Mountjoy, 1970; Wheeler and Gabrielse, 1972; Carrigy, 1971; Eisbacher *et al.*, in press). Because molasse provides a record of the late-orogenic stage of mountain building, comparative studies between molasse belts of different orogens could possibly shed light on the general problems of late-orogenic paleodrainage, uplift, and deformation of growing mountain ranges. In this short review the author attempts a comparison between the molasse of the Columbian Orogen of the Canadian Cordillera and the Alps of central Europe.

Uplift of Crystalline Core Zones
Alps. Radiometric study of the crystalline core region has shown that large scale tectonic transport and penetrative deformation within regionally metamorphosed terrane had virtually ceased before the onset of molasse sedimentation in mid-Oligocene time (Milnes, 1969). Clasts from the distinctly post-orogenic Bergell intrusion (which crystallized 30 m.y. ago) are found in only slightly younger Middle Oligocene conglomerate south of the Alps (Longo, 1968; Gulson and Krogh, 1973). This demonstrates vigorous block uplift of the crystalline core region at this time. The sedimentary folds and thrust sheets of the Helvetic domain north of the crystalline core zone, however, deformed during later stages of molasse deposition (Trümpy, 1973). Radiometric ages from the principal high temperature metamorphic culminations correspond remarkably well with the total time span of molasse deposition (from about 30 m.y. to 10 m.y. ago).

Columbian Orogen. Most of the large scale folding and penetrative deformation within the metamorphic complexes of the core zone had probably ceased prior to the beginning of molasse sedimentation in late Jurassic time (Reesor, 1973; Eisbacher and Gabrielse, in press). Most of the folds that formed during this mid-Jurassic deformation straddle the boundary between the Cordilleran eugeosyncline and miogeosyncline. The fold structures in low-grade metamorphic terranes are generally upright or overturned to the west. In high-grade terrane the axial surfaces of folds lie generally flat. Large discordant batholiths of Early Cretaceous age cut the pre-existing structures and seem to follow deep fracture zones (Gabrielse and Reesor, in press). Most of the easterly directed folds and thrust faults of the Rocky Mountain region formed during a later phase of crustal shortening in Late Cretaceous and Early Tertiary time (Price and Mountjoy, 1970; Eisbacher *et al.*, in press). The time interval covered by radiometric ages within the principal metamorphic complexes of the Omineca Crystalline Belt coincides roughly with the time of molasse deposition (from about 140 m.y. to 40 m.y. ago).

Tectonic Control of River Adjustment

Tectonic structures of an emerging orogen profoundly influence the course of river systems and thus the geometry of molasse deposits. The principal structural controls have been pointed out by Staub (1934) and Eisbacher *et al.* (in press). It appears that (1) deposition along the axis of molasse basins is predominantly longitudinal; (2) major rivers enter the molasse basins through structural re-entrants of the mountain front, transverse fault zones, or metamorphic depressions, and (3) that within the mountain chain drainage commonly follows longitudinal fault zones.

The Molasse Basins

Alps. Two upward coarsening sedimentary megacycles make up the molasse of the northern Alpine foreland basin (Fig. 1). Each of these megacycles was deposited by river systems whose deltas advanced longitudinally along the axis of the foreland basin and were fed by

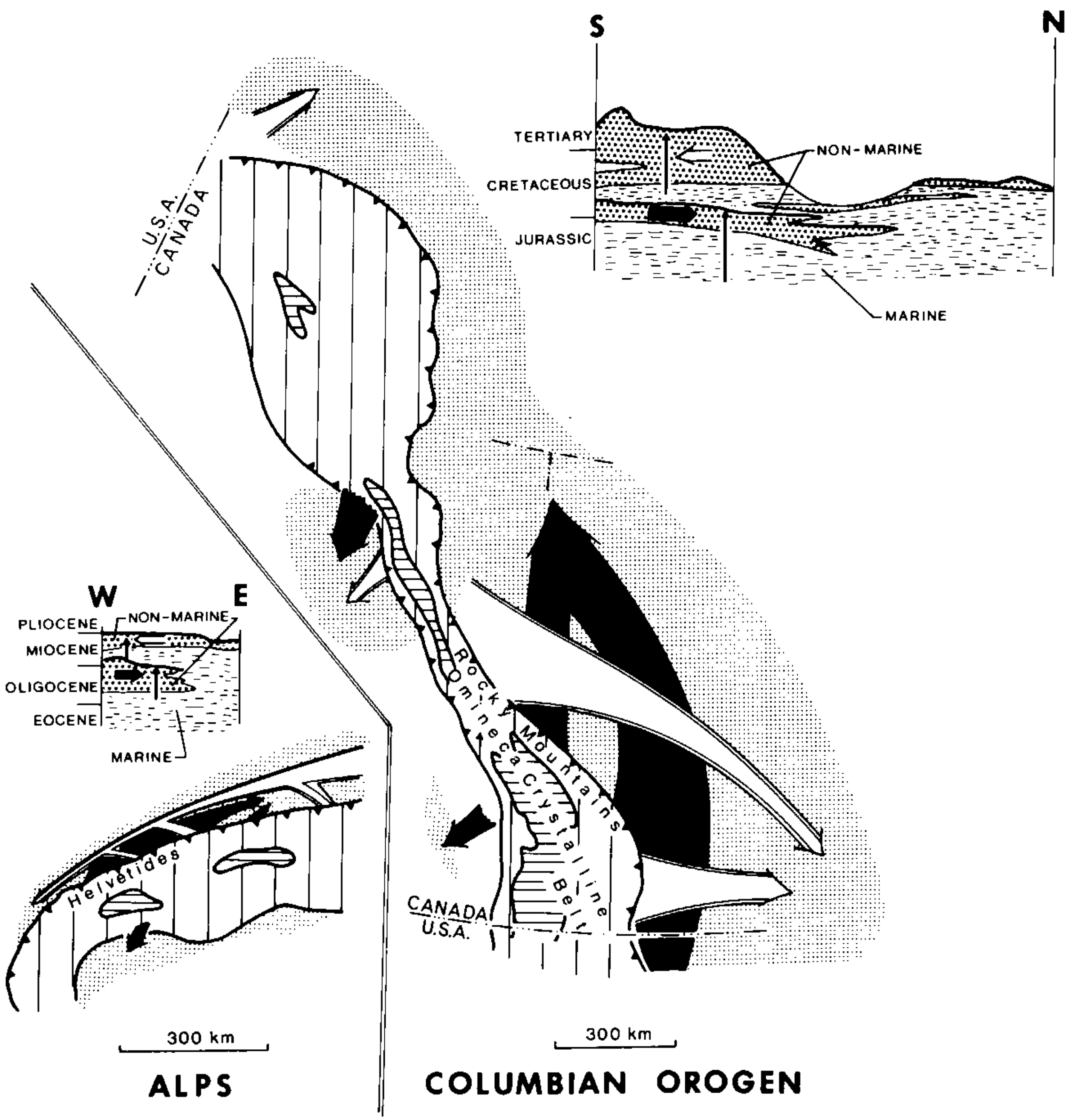

Figure 1
Sketch of the molasse basins (fine dots) adjacent to the Alps of Central Europe and the Columbian Orogen of the Canadian Cordillera. Two longitudinal cross sections illustrate the two sedimentary megacycles in the foreland basins and the direction of sediment dispersal (first megacycle = black arrows, second megacycle = white arrows). Closely spaced ruling indicates major metamorphic complexes that cooled and were uplifted during molasse deposition.

transverse streams from the rising Alps (Füchtbauer, 1967). The two cycles are possibly related to the two major phases of crustal shortening of the central Alpine basement, one in the south (the main "Meso-Alpine" deformation between late upper Eocene and late lower Oligocene), and one in the north ("Neo-Alpine" orogeny of the Helvetide belt), followed by uplift (Trümpy, 1973). Intramontane basins seem to have formed only during the second cycle (Füchtbauer, 1967).

Columbian Orogen. Two upward coarsening megacycles are found in the foreland basin (Fig. 1). The first of these cycles (uppermost Fernie, Kootenay, Blairmore) is possibly related to mid-Jurassic crustal shortening and subsequent uplift in the Omineca Crystalline Belt. The second cycle (Alberta, Belly River, Paskapoo) may be related to deformation of the Rocky Mountains and displacement along steep intramontane fault zones (Eisbacher *et al.*, in press). During the first megacycle deltas advanced northward; during the second phase they prograded southeastward.

Termination of Molasse Deposition

Alps. The youngest molasse phases were blankets of gravel of early Pliocene age along the eastern and northern margin of the mountains (Pannonschotter, Hausruckschotter) and are generally preserved as undeformed caps on older molasse deposits or underlying sedimentary or basement rocks (Winkler-Hermaden, 1957). Following this phase of fluviatile deposition most rivers began to cut into their own deposits and the molasse "basin" adjacent to the Alps ceased to exist. The Po basin to the south and the Pannonian Basin to the east of the Alps are still receiving sediment. Subsidence in these areas, however, is probably related to recent orogenic activity in the northern Apennines and the eastern Carpathians.

Columbian Orogen. The youngest molasse deposits are remnants of formerly extensive gravel sheets of braided foreland streams and intramontane alluvial fans of early Oligocene and possibly younger age (Von Hof, 1965; Carrigy, 1971). In post-Oligocene time regional uplift initiated entrenchment of large streams and most of the detritus from the Columbian Orogen was carried directly to the Atlantic, Pacific, and Arctic Oceans or into Hudson Bay.

Differences between Alpine and Columbian Molasse

Although great similarities exist between the upward and outward coarsening molasse of the Alps and the Columbian Orogen, there are marked differences as well. Although both successions attain thinknesses between 3,000 and 6,000 meters (Füchtbauer, 1967; Price and Mountjoy, 1970), the span of time during which they were deposited and size of the basins differs by a factor of three or four (Fig. 1). There is also a distinct difference in the paleoclimatic setting of these two molasse successions. In the Columbian molasse coal deposits are extensive and redbeds are rare (Holter and Mellon, 1972; Eisbacher, 1974; Steiner *et al.*, 1972). In the Alpine molasse redbeds are very common and coal deposits are regionally and stratigraphically restricted.

Conclusion

Deposition of the molasse facies adjacent to the Alps and alongside the Columbian Orogen coincides in time with the rise, cooling and initial unroofing of large regional metamorphic complexes within the core of the respective orogens. In both cases, deposition follows major crustal shortening along the eugeosynclinal side of the orogen and overlaps the time of tectonic displacements along the miogeoclinal side of the orogen. Emplacement of post-deformational granitic batholiths along fracture zones coincides with the transition from flysch to molasse facies. Late-orogenic drainage along the axis of the foreland basins was in both cases longitudinal. The youngest K-Ar and Rb-Sr dates from the regionally metamorphosed core zones signal the termination of molasse deposition which in both orogens is followed by extensive uplift and erosion of molasse deposits.

References

Carrigy, M. A., 1971, Lithostratigraphy of the uppermost Cretaceous (Lance) and Paleocene strata of the Alberta Plains: Res. Counc. Alberta Geol. Div. Bull. 27, 161 p.

Eisbacher, G. H. and H. Gabrielse, 1974, The molasse facies of the Canadian Cordillera: Geol.Rundsch., in press.

Eisbacher, G. H., M. A. Carrigy and R. B. Campbell, 1974, Paleodrainage pattern and late-orogenic basins of the Canadian Cordillera: *in* W. R. Dickinson, ed., Tectonics and Sedimentation: Soc. Econ. Paleonto. Mineral., Spec. Publ. 20, in press.

Eisbacher, G. H., 1974, Deltaic sedimentation in the northeastern Bowser Basin, British Columbia: Geol. Surv. Can. Paper 73-33, 13 p.

Füchtbauer, H., 1967, Die Sandsteine in der Molasse nördlich der Alpen: Geol. Rundsch., v. 56, p. 266-300.

Gabrielse, H. and J. E. Reesor, 1974, The nature and setting of granitic plutons in the central and eastern parts of the Canadian Cordillera: Pacific Geol., in press.

Gansser, A., 1964, Geology of the Himalayas: London, Interscience Pub., 289 p.

Gulson, B. L. and T. E. Krogh, 1973, Old lead components in the young Bergell massif, southeast Swiss Alps: Contrib. Mineral. Petrology, v. 40, p. 239-252.

Heim, A., 1919, Geologie der Schweiz: v. 1, p. 1-198. Leipzig, Verl. Fauchnitz.

Hoffman, P. F., J. A. Fraser and J. C. McGlynn, 1970, The Coronation Geosyncline of Aphebian age, District of Mackenzie: *in* A. J. Baer, ed., Symposium on Basins and Geosynclines of the Canadian Shield, Geol. Surv. Can. Paper 70-40, p. 201-212.

Holter, M. E. and G. B. Mellon, 1972, Geology of the Luscar (Blairmore) coal beds, central Alberta Foothills: *in* Proceedings of First Geological Conference on Western Canadian Coals: Res. Counc. Alberta, Inf. Ser. no. 60, p. 125-135.

Hsu, K. J., 1970, The meaning of the word Flysch – a short historical search, *in* Jean Lajoie, ed., Flysch Sedimentology in North America: Geol. Assoc. Can., Spec. Paper 7, p. 1-11.

Longo, V., 1968, Geologie und Stratigraphie des Gebietes zwischen Chiasso und Varese: Univ. Zurich, Ph.D. Thesis, 181 p.

Mazarovich, O. A., 1972, Geotectonic conditions for the formation of molasse: Geotectonics, 1972, no. 1, p. 14-21.

Milnes, A. G., 1969, On the orogenic history of the Central Alps: Jour. Geol., v. 77, p. 108-112.

Potter, P. E. and F. J. Pettijohn, 1963, Paleocurrents and basin analysis: New York, Springer Verlag, Academic Press Inc., 296 p.

Price, R. A. and E. W. Mountjoy, 1970, Geologic structure of the Canadian Rocky Mountains between Bow and Athabaska Rivers – a progress report: *in* Structure of the Southern Canadian Cordillera: Geol. Assoc. Can. Spec. Paper 6, p. 7-25.

Reesor, J. E., 1973, Geology of the Lardeau map-area, east half, British Columbia: Geol. Surv. Can. Memoir 369, 129 p.

Staub, R., 1934, Grundzüge und Probleme alpiner Morphologie: Denkschr. d. Schweizer. Naturf. Ges., v. 69, Abt. 1, 183 p.

Steiner, J., G. D. Williams, G. J. Dickie, 1972, Coal deposits of the Alberta Plains, *in* Proceedings of the First Conference on Western Canadian Coal: Res. Counc. Alberta Inf. Ser. 60, p. 85-108.

Stöcklin, J., 1968, Structural history and tectonics of Iran: a review: Am. Assoc. Petrol. Geol. Bull., v. 52, p. 1229-1258.

Studer, B., 1825, Beytraege zu einer Monographie der Molasse: Bern, C. A. Jenni, 427 p.

Trümpy, R., 1973, The timing of orogenic events in the Central Alps: *in* K. A. DeJong and R. Scholten, ed., Gravity and Tectonics, p. 229-251.

Van Houten, F. B., 1973, Meaning of molasse: Geol. Soc. Am. Bull., v. 84, p. 1973-1976.

Van Houten, F. B. and R. B. Travis, 1968, Cenozoic deposits, Upper Magdalena Valley, Colombia: Am. Assoc. Petrol. Geol. Bull., v. 52, p. 675-702.

Vonhof, J. A., 1965, The Cypress Hills Formation and its reworked deposits in southwestern Saskatchewan: Alberta Soc. Petroleum Geol., 15th Ann. Field Conference, part 1, p. 142-161.

Wheeler, J. O. and H. Gabrielse, 1972, Cordilleran Structural Province: *in* R. A. Price and R. J. Douglas, ed., Variations in Tectonic Styles in Canada: Geol. Assoc. Can. Spec. Paper 11, p. 1-81.

Winkler-Hermaden, A., 1957, Geologisches Kraeftespiel und Landformung: Wien, Springer Verlag, 822 p.

MS received, May 6, 1974.