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the Himalayan frontal thrusts with the probably synchronous Kishtwar and Larji-Kullu-Rampur domes in the middle of the High Himalaya. The models of Beaumont et al. (1994, 1996) and Escher & Beaumont (1997) suggest that the initiation of up-warping at the backstop may be controlled by reduction in the convergent material that can be accommodated by the subduction channel. During the late orogenic and active Himalayan phase of dextral transpression between India and Asia, the dome structures continue to be uplifted and are often limited by younger normal faults and flexures such as the N-striking Tso Moriri fault and the Tso Kar and Yurdi flexures. The latter is together with the WNW-striking Sanku flexure responsible for the active uplift of the Suru syntaxis (Suru dome).

### Conclusion

In conclusion, the Himalayan range was built up during the convergence of the Indian and Asian plates by a typical succession of orogenic phases (Masclé 1985, Le Fort 1996, Hodges 2000), where the preceding phase influences the next younger one. The main phases of the NW Himalaya are enumerated in the following list:

- 1) The Late Cretaceous and Paleocene **Transhimalayan batholith phase** (prothimalayan phase, Hodges 2000), characterised by the 103-50 Ma Andean type Ladakh magmatism, the accretion of the Dras-Nindam arc, the accretion and later obduction of the Spongtang immature island arc forming the southern active border of Asia and forearc sediment deposition. The Transhimalayan batholith, together with the Asian mantle wedge, form the Asian backstop for the Himalayan range.
- 2) The **Shikar Beh phase**: the intra continental NE-verging Shikar Beh range of an unknown, probably late Paleocene age,
- 3) The Eocene **North Himalayan phase** (eohimalayan phase, Hodges 2000) creating the SW-directed North Himalayan accretionary wedge.
- 4) The late Eocene-Miocene **High Himalayan phase** (neohimalayan phase, Hodges 2000): The zone of dry intra-crustal melting below the North Himalayan range and the Shikar Beh nappe stack determined the future position of the Main Central thrust at the base of the High Himalayan or "Crystalline" nappe.
- 5) The late Miocene to present **Lesser Himalayan phase**, with the formation of the deep-seated intracrustal Main boundary thrust.
- 6) The active **Subhimalayan phase** with the Subhimalayan thrust in front and the Active Himalayan thrust at the base of the present Himalayan accretionary wedge.

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### REFERENCES

- AGRARWAL, R.P. 1993: Geology and Biostratigraphy of the Upper Siwalik of Samba area, Jammu Foothills. *J. Himalayan Geol.* 4, 227-236.
- ALSDORF, D., BROWN, L., NELSON, K.D., MAKOVSKY, Y. KLEMPERER, S. & ZHAO, W. 1998: Crustal deformation of the Lhasa terrane, Tibet plateau from Project INDEPTH deep seismic reflection profiles. *Tectonics* 17, 501-519.
- APPEL, E., MÜLLER, R. & WIDDER, R.W. 1991: Paleomagnetic results from the Tibetan sedimentary series of the Manang area (north central Nepal). *Geophys. J. Int.* 104, 255-266.
- APPEL, E., PATZELT, A. & CHOUKER, C. 1995: Secondary palaeoremanence of Tethyan sediments from the Zaskar Range (NW Himalaya). *Geophys. J. Int.* 122: 227-242.
- ARGAND, E. 1924: La tectonique de l'Asie. *Congr. géol. int. Bruxelles 1922, XIIIe session.* 171-372.
- AUDEN, J.B. 1934: The Geology of the Krol belt. *Rec. Geol. Surv. India* 67/4 357-454.
- AVOUAC, J.P., BOLLINGER, L., LAVÉ, J., CATTIN, R. & FLOUZAT, M. 2001: Le cycle sismique en Himalaya. *C.R. Acad. Sci. (Paris)* 333, 513-529.
- AZMI, R.J. & PANCHOLI, V.P. 1983: Early Cambrian (Tommotian) conodonts and other shelly microfauna from the Upper Krol of Mussoorie Syncline, Garhwal Lesser Himalaya, with remarks on the Pricambrian-Cambrian boundary. *Himalayan Geol.* 11, 360-372.
- BAGATI, T.N. 1990: Lithostratigraphy and facies variation in the Spiti basin (Tethys), Himachal Pradesh, India. *J. Himalayan Geol.* 1, 35-47.
- BAGATI, T.N. 1991: Evolution of the Tethyan sedimentary basin in the western Himalaya. In: S.K. TANDON, C.C. PANT & S.M. CASSHYAP (eds.): *Sedimentary basins of India, tectonic context.* Gyanodaya Prakashan, Nainital, 218-235.
- BASSOULET, J.P., BELLIER, J.P., COLCHEN, M., MARCOUX, J. & MASCLÉ, G. 1978a: Découverte de Crétacé supérieur calcaire pélagique dans le Zaskar (Himalaya du Ladakh). *Bull. Soc. géol. France*, 7/20, 961-964.
- BASSOULET, J.P., COLCHEN, M., MARCOUX, J. & MASCLÉ, G. 1978b: Une transversale de la zone de l'Indus de Khalsi à Phothaksar, Himalaya du Ladakh. *C.R. Acad. Sci. (Paris)* 286, série D, 563-566.
- BASSOULET, J.P., COLCHEN, M., JUTEAU, TH., MARCOUX, J. ET MASCLÉ, G. 1980: L'édifice des nappes du Zaskar (Ladakh-Himalaya). *C.R. Acad. Sci. (Paris)* 290D, 389-392.
- COLCHEN, M., JUTEAU, T., MARCOUX, J., MASCLÉ, G. & REIBEL, G. 1983: Geological studies in the Indus Suture Zone of Ladakh (Himalaya). In: GUPTA, V.J. (Ed.): *Stratigraphy and Structure of Kashmir and Ladakh, Himalaya.* (p. 96-124). – Hindustan. Publ. Corp., Delhi.
- BASSOULET, J.P., COLCHEN, M., GILBERT, E., MARCOUX, J., MASCLÉ, G., SUTRE, E. & VAN HAVER, T. 1984: L'orogène himalayen au Crétacé. *Mém. Soc. géol. France*, N.S. 147, 9-20.
- BAUD, A., ARN, R., BUGNON, P., CRISINEL, A., DOLIVO, E., ESCHER, A., HAMMERSCHLAG, J.G., MARTHALER, M., MASSON, H., STECK, A. & TIÈCHE, J.C. 1982: Le contact Gondwana-péri-Gondwana dans le Zaskar oriental (Ladakh, Himalaya). *Bull. Soc. géol. France*, 24, 341-361.
- BAUD, A., ATUDOREI, V. & SHARP, Z. 1996: Late Permian and Early Triassic Evolution of the Northern Indian margin: Carbon Isotope and Sequence Stratigraphy. *Geodynamica Acta* 9, 57-77.
- GAETANI, M., GARZANTI, E., FOIS, E., NICORA, A. & TINTORI, A. 1984: Geological observations in southeastern Zaskar and adjacent Lahul area (northwestern Himalaya). *Eclogae geol. Helv.* 77, 171-197.

- BEAUMONT, C., ELLIS, S., HAMILTON, J. & FULLSACK, P. 1996: Mechanical model for subduction-collision of Alpine-type compressional orogens. *Geology* 24, 675–678.
- FULLSACK, P. & HAMILTON, J. 1994: Styles of crustal deformation in compressional orogens caused by subduction of the underlying lithosphere. *Tectonophysics* 232, 119–132.
- JAMIESON, R.A., NGUYEN, M.H. & LEE, B. 2001: Himalayan tectonics explained by extrusion of a low-viscosity crustal channel coupled to focused surface denudation. *Nature* 414, 738–742.
- BECCALUVA, L., OHNSTETTER, D. & OHNSTETTER, M. 1973: Geochemical discrimination between ocean floor and island arc tholeiites; application to some ophiolites. *Ophioliti* 4, 67–72.
- BERGERAT, F. 1987: Paléo-champs de contrainte tertiaires dans la plate-forme européenne au front de l'orogène alpin. *Bull. Soc. géol. Fr.* 8, 611–620.
- BERTHELSEN, A. 1951: A geological section through the Himalaya. *Medd. dansk geol. Foren. (København)* 12, 102–104.
- BERTHELSEN, A. 1953: On the geology of the Rupshu district, N.W. Himalaya. *Medd. dansk geol. Foren. (København)* 12, 351–414.
- BESSE, J., COURTILOT, V., POZZI, J.P., WESTPHAL, M. & ZHOU, Y.K. 1984: Palaeomagnetic estimates of crustal shortening in the Himalayan thrusts and Zangpo suture. *Nature* 311, 621–626.
- BHARGAVA, O.N. 1980: The tectonic windows of the Lesser Himalaya. *Himalayan Geol.* 10, 135–155.
- BHARGAVA, O.N. 1980: Outline of the stratigraphy of Eastern Himachal Pradesh, with special reference to the Jutogh Group. In: VALDIA K.S. & BHATIA S.B. (Ed.): *Stratigraphy and correlations of Lesser Himalayan Formations.*, Hindustan Publ. Corp. New Delhi, 117–125.
- BHARGAVA, O.N. 1987: Lithostratigraphy microfacies and palaeoenvironment of Scythian-Dogger Lilang Group, Spiti valley, Himachal Himalaya. *J. Pal. Soc. India* 32, 92–107.
- BHAT, M.I. & LE FORT, P. 1992: Sm-Nd age and petrogenesis of Rampur metavolcanic rocks, NW Himalayas: Late Archaean relics in the Himalayan belt. *Precambrian Res.* 56, 191–210.
- ZAINUDDIN, S.M. 1979: Origin and evolution of Panjal volcanics. *Himalayan Geol. (Dehra Dun)* 9, 421–461.
- BHATIA, S.B. (1980): The Tal Tangle. In Bathia & Valdiya (eds): *Stratigraphy and correlations of Lesser Himalayan Formations.* Hindustan Publishing Corporation, Delhi, 79–98.
- BHATIA, S.B. 2000: Faunal and floral diversity in the Subathu-Dagshai Passage Beds: a Review. *Himalayan Geology*, 21, 87–97.
- BHATIA, S.B. & BHARGAVA, O.N. 2002: Age and provenance of the Paleogene sediments of the Himalayan, Foreland Basin: paleontological constraints. Abstracts: 17<sup>th</sup> Himalaya-Karakorum-Tibet Workshop, India, 2–4.
- BHATT, D.K. 1975: On the Quaternary geology of the Kashmir Valley with special reference to stratigraphy and sedimentation. In: *Recent geological studies in the Himalayas*, Miscellaneous Publications, Geol. Surv. India. 24/1, 188–203.
- MATHUR, A.K. 1990: Small shelly fossils of Precambrian-Cambrian boundary beds from the Krol-Tal succession in Nainital syncline, Lesser Himalaya. *Curr. Sci.* 59, 218–222.
- FUCHS, G., PRASHRA, K.C., KRYSSTYN, L. ARORA, R.K. & GOLEBIOWSKI, R. 1980: Additional ammonoid layers in the Upper Permian sequence of Spiti. *Bull. Indian Geol. Assoc. (Chandigarh)* 13, 57–61.
- MAMGAIN, V.D., MISRA, R.S. & SRIVASTAVA, J.P. 1983: Shelly microfauna of Tommotian (Lower Cambrian) age from chert-phosphorite member of Lower Tal Formation, Maldeota, Dehradun, U.P. *Geophytology* 13, 116–123.
- MATHUR, A.K. 1990: Small shelly fossils of Precambrian-Cambrian boundary beds from Krol-Tal succession in the Nainital syncline, Lesser Himalaya. *Curr. Sci.* 59, 218–222.
- BLONDEAU, A., BASSOULET, J.P., COLCHEN, M., HAN TON LIN, MARCOUX, J., MASCLE, G. & VAN HAVER, T. 1986: Disparition des formations marines à l'Eocène inférieur en Himalaya. *Sci. Terre Mém., Nancy* 47, 103–111.
- BONHOMME, M. & GARZANTI, E. 1991: Age of metamorphism in the Zaskar Tethys Himalaya (India). *Géol. alp. (Grenoble), Mém. H. S.* 16, 15–16.
- BORDET, P., COLCHEN, M., KRUMMENACHER, D., LE FORT, P., MOUTERDE, R. & REMY, M. 1971: Recherches géologiques dans l'Himalaya du Nepal, région de la Thakkola. *Centre natl. Rech. Sci. Paris*, 279p.
- BOSSART, P. & OTTIGER, R. 1989: Rocks of the Murree formation in northern Pakistan: indicators of descending foreland basin of late Paleocene to middle Eocene age. *Eclogae geol. Helv.* 82, 133–165.
- BOTT, M.H.P. 1982: The interior of the earth: its structure, constitution and evolution. Edward Arnold, Durnham.
- BOUSQUET R., GOFFE, B., HENRY, P., LE PICHON, X. & CHOPIN, C. 1997: Kinematic, thermal, and petrological model of the Central Alps: Lepontine Metamorphism in the upper crust and eclogitisation of the lower crust. *Tectonophysics* 273, 105–127.
- BROOKFIELD, M.E. 1993: The Himalayan passive margin from Precambrian to Cretaceous times. *Sediment. Geol.* 84, 1–35.
- BROOKFIELD, M.E. & ANDREWS-SPEED, C.P. 1984: Sedimentology, petrography and tectonic significance of the shelf, flysch and molasse clastic deposits across the Indus suture zone, Ladakh, NW India. *Sediment. Geol.* 40, 249–286.
- BUCHER, H. & STECK, A. 1987: Stratigraphy and tectonics of the Indus basin: the Martselang-Gongmaru La section (Ladakh). *Terra Cognita* 7, 112.
- BURBANK, D.W., BECK, R.A. AND MULDER, T. 1996: The Himalayan foreland basin. In: YIN, A. & HARRISON, T.M. (Ed.): *The Tectonic Evolution of Asia*, p. 149–188.
- BURCHFIELD, B.C., CHEN ZHILIANG, HODGES, K.V., LIU YUPING, ROYDEN, L.H., DENG CHANGRONG & XU JIENE 1992: The south Tibetan detachment system, Himalayan Orogen: Extension contemporaneous with and parallel to shortening in a collisional mountain belt. *Spec. Pap. geol. Soc. Amer.* 269, 1–41.
- BURCHFIELD, B.C. & ROYDEN, L.H. 1985: North-south extension within the convergent Himalayan region. *Geology*, 13, 679–682.
- BURG, J.P. & CHENG, G.M. 1984: Tectonics and structural zonation of southern Tibet, China. *Nature (London)* 311, 219–223.
- CABY, R., PÉCHER, A. & LE FORT, P. 1983: Le grand chevauchement central himalayen: nouvelles données sur le métamorphisme inverse à la base de la dalle du Tibet. *Revue de Géol. Dynam. Géogr. Phys. Paris* 24, 89–100.
- CANDE, S.C. & KENT, D.V. 1992: A new geomagnetic polarity time scale for the Late Cretaceous and Cenozoic. *J. Geophys. Res.* 97, 13917–13951.
- CANNAT, M. & MASCLE G. 1990: Réunion extraordinaire de la Société géologique de France en Himalaya du Ladakh. *Bull. Soc. géol. France* 4, 553–582.
- CATLOS, E.J., HARRISON, T.M., MANNING, C.E., GROVE, M., RAI, S.M., HUBBARD, S.M. & UPRETI, B.N. 2002: Records of the evolution of the Himalayan orogen from in situ Th-Pb ion microprobe dating of monazite: Eastern Nepal and western Garhwal. *J. Asian Earth Sci.* 20: 459–479.
- CHAUDHRI, R.S. 1972: Heavy mineral markers from the Siwalik Formations of Panjab Himalaya. *Geol. Mag.* 105, 421–430.
- CHEMENDA, A.I., MATTAUER, M., MALAVIELLE, J. & BOKUN, A.N. 1995: A mechanism for syn-collisional rock exhumation and associated normal faulting: Results from physical modelling. *Earth planet. Sci. Lett.* 132, 225–232.
- CHOUBEY, V.M., SHARMA, K.K. & RAMESHWAR, R. 1994: Crustal anatexis and petrogenesis of the granitoid rocks, Chor region, Himachal Himalaya. *J. Himalayan Geol.* 5, 1–9.
- COLCHEN, M. 1999: The Thakkola-Mustang graben in Nepal and the late Cenozoic extension in the Higher Himalayas. *J. Asian Earth Sci.* 17, 683–702.
- LE FORT, P. & PÉCHER, A. 1986: Geological research in the Nepal Himalaya: Annapurna-Manaslu-Ganesh Himal, notice of the geological map on 1/200'000. *Cent. Nat. de la Recherche Sci. Paris.*
- MASCLE, G. & DELAYGUE, G. 1994: Lithostratigraphy and age of the formations in the Tso Morari dome. *J. of the Nepal Geol. Soc.* 10, 23.
- REUBER, I. 1987: Obduction of the Spongtang klippe traced by stratigraphic data of the underlying melange, Ladakh-Himalaya. *Terra Cognita* 7, 111.
- CORFIELD, R.I. & SEARLE, M.P. 2000: Crustal shortening estimates across the north Indian continental margin, Ladakh, NW India. In: KHAN, M.A., TRELOAR, P.J., SEARLE, M.P. & JAN, M.Q. (eds.), *Tectonics of the Nanga Parbat syntaxis and the Western Himalaya.* *Geol. Soc. London Spec. Publ.* 170, 395–410.

- SEARLE, M.P. & GREEN, O.R. 1999: Photang thrust sheet: an accretionary complex structurally below the Spongtang ophiolite constraining timing and tectonic environment of ophiolite obduction, Ladakh Himalaya, NW India. *J. geol. Soc. London* 156, 1031–1044.
- DAINELLI, G. 1933–1934: Spedizione italiana de Filippi nell'Himalaia, Caracorum e Turchestan cinese (1913–1914). Ser. 2, Risultati geologici e geografici. Vol. 2, La serie dei Terreni, 1, 1–458, 2, 459–1105. Zanichelli, Bologna.
- DECELLES, P.G., GEHRELS, G.E., QUADE, J. & OJHA, T.P. 1998a: Eocene-early Miocene foreland basin development and the history of Himalayan thrusting, western and central Nepal. *Tectonics* 17, 741–765.
- GEHRELS, G.E., QUADE, J., OJHA, T.P. & KAPP, P.A. 1998b: Neogene foreland basin deposits, erosional unroofing, and the kinematic history of the Himalayan fold-thrust belt, western Nepal. *Geol. Soc. Amer. Bulletin* 110, 2–21.
- GILES, K.A. 1996: Foreland basin systems. *Basin Research* 8, 105–123.
- DE SIGOYER, J., GUILLOT, S., LARDEAUX, I.M. & MASCLE G. 1997: Glauco-phane-bearing eclogites in the Tso Morari dome (eastern Ladakh, NW Himalaya). *European J. of Mineral.* 9, 1073–1083.
- CHAVAGNAC, V., Blichert-Toft, J., VILLA, I.M., LUIS, P., GUILLOT, S., COSCA, M. & MASCLE G. 2000: Dating the Indian continental subduction and collisional thickening in the northwest Himalaya: Multichronology of the Tso Morari eclogites. *Geology* 28, 487–490.
- DEWEY, J.F., CANDE, S. & PITMAN III, W.C. 1989: Tectonic evolution of the India/Eurasia Collision Zone. *Eclogae geol. Helv.* 82, 717–734.
- DÈZES, P. (1999): Tectonic and metamorphic evolution of the Central Himalayan domain in southeast Zaskar (Kashmir, India), *Mém. géol.* n° 32, Lausanne.
- VANNAY, J.C., STECK, A., BUSSY, F. & COSCA, M. 1999: Synorogenic extension; quantitative constraints on the age and throw of the Zaskar Shear Zone (NW Himalayas). *Geological Society of America Bulletin* 111, 364–374.
- DIENER, C. 1908: Ladinic, Carnic and Noric faunae of Spiti. *Palaeont. Indica*, s. 15, v. 5, Mem. 3, 157 pp., Calcutta.
- DIETRICH, V.J., FRANK, W. & HONEGGER, K. 1983: A Jurassic-Cretaceous island arc in the Ladakh-Himakayas. *J. Volc. Geotherm. Res.* 18, 405–433.
- DRAGANITS, E. 2000: The Muth Formation in the Pin Valley (Spiti, N-India): Depositional environment and Ichnofauna of a Lower Devonian Barrier Island System. Ph.D. thesis, University Vienna.
- GRASEMANN, B., FRANK, W., MILLER, CH. & WIESMAYR, G. 1998: The sedimentary protoliths of the HHC in the Chamba-Lahul area, NW-Himalayas, India. HKT-workshop Abstracts, *Geol. Bull. Univerity of Peshawar*, 31, 58–60.
- Mawson, R., Talent, J.A. & Krystyn L. 2002: Lithostratigraphy, conodont biostratigraphy and depositional environment of middle Devonian (Givetian) to Early Carboniferous (Tournaisian) Lipak Formation in the Pin Valley of Spiti (NW India). *Rivista Italiana Paleont. Strat.* 108, 7–35.
- ELLIOTT, T. 1986: Deltas. In: Reading, H.R. (Ed.): *sedimentary environments and facies*, Blackwell Sci. Publ. Oxford, 113–154.
- EPARD, J.-L., STECK, A., VANNAY, J.-C. & HUNZIKER J. 1995: Tertiary Himalayan structures and metamorphism in the Kulu Valley (Mandi-Khok-sar transect of the Western Himalaya) – Shikar Beh Nappe and Crystalline Nappe. *Schweiz. mineral. petrogr. Mitt.* 75, 59–84.
- MASSON, H., PERRIN, M., ASIS-LOPEZ, M. & CASTELLA, J. 1997: Le logiciel POLYPLI: un support pour l'interprétation et la modélisation des terrains profonds. *Documents du BRGM*, 274, 33–36.
- STECK, A. in press: The eastern continuation of the Zaskar shear zone *Eclogae geol. Helv.*
- ESCHER, A. & BEAUMONT, C. 1997: Formation, burial and exhumation of basement nappes at crustal scale: a geometric model based on the Western Swiss-Italian Alps. *J. Struct. Geol.* 19, 955–974.
- MASSON, H. & STECK, A. 1988: Coupes géologiques des Alpes occidentales suisses. *Mém. Géol.* 2, Lausanne.
- FIESTMANTEL, O. 1882: Note on the remains of palm leaves from the Tertiary Murree and Kasauli beds in India. *Geol. Surv. India Records*, 15, 51–53.
- FOSTER, G., VANCE, D., ARGLES, T. & HARRIS, N. 2002: The Tertiary collision-related thermal history of the NW Himalaya. *J. metamorphic Geol.* 20, 827–843.
- FRANK, W., BAUD, A., HONEGGER, K. & TROMMSDORFF, V. 1987: Comparative studies on profiles across the northwest Himalayas. In: SCHAEER, J.-P. & RODGERS, J. (Ed.): *The anatomy of mountain ranges* (p. 261–275). - Princeton Univ. Press, Princeton New Jersey.
- FUCHS, G. 1970: Geological investigations in west Nepal and their significance for the geology of the Himalayas. *Geol. Rdsch.* 59, 552–580.
- GANSSER, A. & TROMMSDORFF, V. 1977a: Geological observations in the Ladakh area (Himalayas). A preliminary report. *Schweiz. mineral. petrogr. Mitt.* 57, 89–113.
- GRASEMANN, B., GUNTALI, P. & MILLER, C. 1995: Geological Map of the Kishtwar-Chamba-Kulu Region (NW Himalayas, India). *Jb. Geol. Bundesanstalt, Wien* 138/2, 299–308.
- HOINKES, G., MILLER, C., PURTSCHELLER, F., RICHTER, W. & THÖNI, M. 1973: Relations between metamorphism and Orogeny in a Typical Section of the Indian Himalayas. *Tschermaks Mineral. Petrogr. Mitt.* 20, 303–332.
- THÖNI, M. & PURTSCHELLER, F. 1977b: Geology and petrography of Kulu-South Lahul area. *Colloq. int. CNRS (Paris)* 268, 147–160.
- BHARGAVA, O.N. & BERTLE, R. 2001: The Geology of Chakrata. *J. Asian Earth Sci.* 19/3A, 18.
- BHARGAVA, O.N., MILLER, CH. & BANERJEE, D.N. 2001: A review of the Proterozoic in the Himalaya and the Northern Indian Shield. *J. Asian Earth Sci.* 19/3A, 17–18.
- FUCHS, G. 1975: Contributions to the geology of the North-Western Himalayas. *Abh. Geol. Bundesanstalt, Wien* 32, 59 p.
- 1977: The Geology of the Karnali and Dolpo Regions, Western Nepal. *Jb. Geol. Bundesanstalt, Wien* 20, 165–217.
- 1979: On the Geology of western Ladakh. *Jb. Geol. Bundesanstalt, Wien* 122, 513–540.
- 1981: Outline of the Geology of the Himalaya. *Mitt. Österr. Geol. Ges. Bd. 74*, 1001–127.
- 1982: The geology of western Zaskar. *Jb. Geol. Bundesanstalt, Wien* 125, 1–50.
- 1983: The Chail Thrust and Chail Nappes in the Himalaya. In *Himalayan Shears* (ed. Saklani, P.S.) Himalayan Books, 33–41.
- 1986: The geology of the Markha – Khurnak region in Ladakh (India). *Jahrb. Geol. Bundesanstalt Wien*, 128, 403–437.
- 1987: The geology of Southern Zaskar (Ladakh)-Evidence for the autochthony of the Tethys zone of the Himalaya. *Jb. Geol. Bundesanstalt, Wien* 130, 465–491.
- 1989: Arguments for the autochthony of the Tibetan Zone. *Eclogae geol. Helv.* 82, 685–692.
- & LINNER, M. 1995: Geological Traverse Across the Western Himalaya – a Contribution to the Geology of Eastern Ladakh, Lahul, and Chamba. *Jb. Geol. Bundesanstalt, Wien* 138, 655–685.
- & LINNER, M. 1996: On the Geology of the Suture Zone and Tso Morari Dome in Eastern Ladakh (Himalaya). *Jb. Geol. Bundesanstalt, Wien* 139, 191–207.
- & SHINA, A.K. 1978: The Tectonics of the Garhwal-Kumaun Lesser Himalaya. *Jb. Geol. Bundesanstalt, Wien* 121, 219–241.
- GAETANI, M., CASNEDI, R., FOIS, E., GARZANTI, E., JADOUL, F., NICORA, A. & TINTORI, A. 1985: Stratigraphy on the Tethys Himalaya in Zaskar, Ladakh. *Riv. ital. Paleont. (Stratigr.)* 91/4, 443–478.
- CASNEDI, E., FOIS, E., GARZANTI, E., JADOUL, F., NICORA, A. & TINTORI, A. 1986: Stratigraphy of the Tethys Himalaya in Zaskar, Ladakh – Initial report. *Riv. ital. Paleont. Stratigr.* 91, 443–478.
- & GARZANTI, E. 1991: Multicyclic history of the northern India continental margin (Northwestern Himalaya). *Bull. amer. Assoc. Petroleum. Geol.* 75/9, 1427–1446.
- GARZANTI, E. & TINTORI, A. 1990: Permo-Carboniferous stratigraphy in SE Zaskar and NW Lahul (NW Himalaya, India). *Eclogae Geol. Helv.* 83, 143–161.
- GANSSER, A., 1964: *Geology of the Himalayas*. John Wiley, London 289pp.
- GAPAIS, D., PÉCHER, A., GILBERT, E. & BALLÈVRE, M. 1992: Synconvergence spreading of the Higher Himalaya Crystalline in Ladakh. *Tectonics* 11, 1045–1056.
- GARZANTI, E. 1993: Sedimentary evolution and drowning of a passive margin shelf (Giumal Group; Zaskar Tethys Himalaya, India): paleoenviron-

- mental changes during final break-up of Gondwanaland. In: TREALOR P.J. & SEARLE M.P. (eds.) – Himalayan tectonics. Geol. Soc. Spec. Publ. 74, 277–298.
- BAUD, E. & MASCLE, G. 1987: Sedimentary record of the northward flight of India and its collision with Eurasia (Ladakh Himalaya, India). *Geodynamica Acta*, 1, 297–312.
  - CASNEDI, R. & JDOUL, F. 1986: Sedimentary evidence of a Cambro-Ordovician orogenic event in the Northwestern Himalaya. *Sediment. Geol.* 48, 237–265.
  - JADOU, F., NICORA, A. & BERRA, F. 1995: Triassic of Spiti (Tethys Himalaya, N India). *Riv. ital. Paleont. Stratigr.* 101, 267–300.
  - VAN HAVER, T. 1988: The Indus clastics: fore-arc basin sedimentation in the Ladakh Himalaya (India). *Sediment. Geology*, 59, 237–249.
- GILBERT, E. 1986: Evolution structurale d'une chaîne de collision: structures et déformations dans le nord de la plaque indienne en Himalaya du Ladakh. Ph.D. thesis, Université de Poitiers.
- COLCHEN, M., MASCLE, G., REIBEL, G., REUBER, I. & VAN HAVER, T. 1983: Multiphased tectonics in the Indus Suture Zone, Ladakh Himalaya. *Terra Cognita*, 3, 266.
  - & MERLE, O. 1987: Extrusion and radial spreading beyond a closing channel. *J. struct. Geol.* 9, 481–490.
- GIRARD, M. 2001: Metamorphism and tectonics of the transition between non metamorphic Tethyan Himalaya sediments and the North Himalayan Crystalline Zone (Rupshu area, Ladakh, NW India). *Mem. Geol. (Lausanne)* 35
- & BUSSY, F. 1999: Late Pan-African magmatism in the Himalaya: new geochronological and geochemical data from the Ordovician Tso Morari metagranites (Ladakh, NW India). *Schweiz. Mineral. Petrogr. Mitt.* 79, 399–417.
  - STECK, A. & THÉLIN, P. 1999: The Dutung-Thaktote extensional fault zone and nappe structures documented by illite crystallinity and clay-mineral paragenesis in the Tethys Himalaya between Spiti river and Tso Morari, NW India. *Schweiz. Mineral. Petrogr. Mitt.* 79, 419–430.
  - THÉLIN, P. & STECK, A. 2001: Synorogenic extension in the Tethyan Himalaya documented by tectonics and the Kübler index, Lachung La area, NW India. *Clay Minerals* 36, 237–247.
- GOEL, R.K. & NAIR, N.G.K. 1977: The Spiti Ordovician-Silurian succession. *J. Geol. Soc. India* 18, 47–48.
- GOTHAN, W. & SAHNI, B. 1937: Fossil plants from the Po series of Spiti N.W. Himalaya. *Rec. Geol. Surv. India* 22, 195–206.
- GRASEMANN, B., FRITZ, H. & VANNAY, J.C. 1999: Quantitative kinematic flow analysis from the Main Central Thrust Zone (NW-Himalaya, India): implications for a decelerating strain path and the extrusion of orogenic wedges. *J. Struct. Geol.* 21, 837–853.
- GRIESBACH, C.L. 1891: Geology of the Central Himalaya. *Mem. geol. Surv. India (Calcutta)* 23, 1–232.
- GRUJIC, D., CASEY, M., DAVIDSON, C., HOLLISTER, L.S., KÜNDIG, R. PAVLIS, T. & SCHMID, S. 1996: Ductile extrusion of the Higher Himalayan Crystalline in Bhutan: evidence from quartz microfabrics. *Tectonophysics* 260, 21–43.
- HOLLISTER, L.S. & PARRISH, R.R. 2002: Himalayan metamorphic sequence as an orogenic channel: insight from Bhutan. *Earth planet. Sci. Lett.* 198, 177–191.
- GUILLOT, S., LARDEAUX, J.M., MASCLE, G. & COLCHEN, M. 1995: Un nouveau témoin du métamorphisme de haute pression dans la chaîne himalayenne: les eclogites rétomorphosées du Dôme du Tso Morari, (Est Ladakh, Himalaya). *C.R. Acad. Sci. (Paris)* 320, 931–936.
- DE SIGOYER, J., LARDEAUX, J.M. & MASCLE G. 1997: Eclogitic metasediments from the Tso Morari area (Ladakh Himalaya): Evidence for continental subduction during India-Asia convergence. *Contrib. Mineral. Petrol.* 128, 197–212.
- HATTORI, K.H. & DE SIGOYER, J. 2000: Mantle wedge serpentinization and exhumation of eclogites: Insights from eastern Ladakh, northwest Himalaya. *Geology* 28, 199–202.
- GUNTLI, P. 1993: Geologie und Tektonik des Higher und Lesser Himalaya im Gebiet von Kishwar, SE Kashmir (NW Indien). Dissertation Nr 10211 der ETH Zürich, 198 S., Zürich 1993.
- GUPTA, K.R., GERGAN, J.T. & KUMAT, S. 1983: Geochemistry of the volcanic rocks of the Northwestern Himalaya and its bearing on tectonics-a review. In: SINHA, A.K. (Ed.): *Contemporary Geoscientific Researches in Himalaya (Dehra Dun)* 2, 9–18.
- HAQ, B., HARDENBOL, J. & VAIL, P.R. 1987: Chronology of fluctuating sea levels since the Triassic (250 My ago to the present). *Science* 235, 1 156–167.
- HARRISON, T.M., COPLAND, P., KIDD, W.S.F. & YIN, A., 1992: Raising Tibet. *Science*, 255, 1663–1670.
- COPLAND, P., HALL, A., QUADE, J., BURNER, S., OJHA, T.P., & KIDD, W.S.F. 1993: Isotopic preservation of Himalayan/Tibetan uplift, denudation, and climatic histories in two molasse deposits. *J. Geol.* 101, 157–173.
  - GROVE, M., LOVERA, O.M. & CATLOS, E.J. 1998: A model for the origin of Himalayan anatexis and inverted metamorphism. *J. Geophys. Res.* 103, NO. B11, 27017–27032.
  - RYERSON, F.P., LE FORT, P., YIN, A., LOVERA, O.M. & CATLOS, E.J. 1997: A Late Miocene-Pliocene origin for the central Himalayan inverted metamorphism: *Earth Planet. Sci. Lett.* 146, E1-E7.
  - GROVE, M., LOVERA, O.M. & CATLOS, E.J. 1998: A model for the origin of Himalayan anatexis and inverted metamorphism. *J. geophys. Res.* 103, 27,017–27,032.
- HAUCK, M.S., NELSON, K.D., BROWN, L.D., ZHAO, W. & ROSS, A.R. 1998: Crustal structure of the Himalayan orogen at 90° east longitude from Project INDEPTH deep reflection profiles. *Tectonics*, 17, 481–500.
- HAWKESWORTH, C.J., KEMPTON, P.D., RODGERS, M.W., ELLAM, R.M. & VAN CALSTEREN, P.W. 1990: Continental mantle lithosphere and shallow level enrichment processes in Earth's mantle. *Earth and Planet. Sci Lett.* 96, 256–268.
- HAYDEN, H.H. 1904: The Geology of Spiti, with parts of Bashar and Rupshu. *Mem. Geol. Surv. India.* 36, 1–129.
- HEIM, A. & GANSSER, A. 1939: Central Himalaya, geological observations of the Swiss expedition 1936. *Mém. Soc. Helv. Sci. nat.* 73, 1–245.
- HENRY, P., & LE PICHON, X. & GOFFÉ B. 1997: Kinematic, thermal and petrological model of the Himalayas: constraints related to metamorphism within the underthrust Indian crust and topographic elevation. *Tectonophysics* 273, 31–56.
- HERREN, E. 1985: The deformation style in the Higher Himalaya rock sequence-A case study in Zaskar (NW Himalaya). *Himalayan Workshop Abstract Vol.* University of Leicester.
- 1987 a: Northeast-southwest extension within the higher Himalayas (Ladakh, India). *Geology* 15, 409–413.
  - 1987 b: Structures, Deformation and metamorphism of the Zaskar area. Ph.-D. thesis, ETH-Zürich.
- HIRN, A., LEPINE, J.-C., JOBERT, G., SAPIN, M., WITTINGER, G., XIN, X.Z., YUAN, G.A., JING, W.X., WEN, T.J., BAI, X.S., PANDEY, M.R. & TATER, J.M. 1984: Crustal structure and variability of the Himalayan border of Tibet. *Nature (London)* 307, 23–27.
- HODGES, K.V. 2000: Tectonics of the Himalaya and southern Tibet from two perspectives. *GSA Bulletin* 112, 324–350.
- Parrish, R., Housh, T., Lux, D., Burchfiel, B.C., Royden, L. & Chen, Z. 1992: Simultaneous Miocene extension and shortening in the Himalayan orogen. *Science* 258, 1466–1470.
  - Parrish, R.R. & Searle, M.P. 1996: Tectonic evolution of the central Annapurna Range, Nepalese Himalayas. *Tectonics* 15: 1264–1291.
- HONEGGER, K.H. 1983: Strukturen und metamorphose im Zaskar Kristallin. Ph.D. thesis, ETH-Zürich.
- DIETRICH, V., FRANK, W., GANSSER, A., THÖNI, M. & TROMMSDORFF, V. 1982. Magmatism and metamorphism in the Ladakh Himalayas (the Indus-Tsangpo suture zone). *Earth planet. Sci. Lett.* 60, 253–292.
  - LE FORT, P., MASCLE, G. & ZIMMERMANN, J.L. 1989: The blueschists along the Indus Suture Zone in Ladakh, NW Himalaya. *J. metamorphic Geol.* 7, 57–72.
- HUBBARD, M.S. & HARRISON, T.M., 1989: <sup>40</sup>Ar/<sup>39</sup>Ar constraints on deformation and metamorphism in the Main Central Thrust zone and Tibetan Slab, eastern Nepal Himalaya, *Tectonics* 8: 865–880.
- HUGHES, N.C. & JELL, P.A. 1999: Biostratigraphy and biogeography of Himalayan Cambrian trilobites. *Geol. Soc. America Spec. Paper* 328, 109–116.

- HUIQI, L., MCCLAY, K.R. & POWELL, D. 1992: Physical models of thrust wedges. In: MCCLAY, K.R. (ed.): *Thrust Tectonics*. Chapman & Hall, London, 71–81.
- JADOUL, F., GARZANTI, E. & FOIS, E. 1990: Upper Triassic- lower Jurassic stratigraphy and paleogeographic evolution of the Zaskar Tethys Himalaya (Zangla Unit). *Riv. ital. Paleont. (Stratigr.)* 95, 351–396.
- JAEGER, J.J., COURTILOT, V. & TAPPONNIER, P. 1989: Paleontological view of the ages of the Deccan Traps, the Cretaceous/Tertiary boundary, and the India-Asia collision. *Geology* 17, 316–319.
- JAIN, A.K. & ANAND A. 1988: Deformational and strain patterns of an intra-continental collision ductile shear zone-an example from the Higher Garhwal Himalaya. *J. Struct. Geol.* 10, 717–734.
- KUMAR, D., SINGH, S., KUMAR, A. & LAL, N. 2000: Timing, quantification and tectonic modelling of Pliocene-Quaternary movements in the NW Himalaya: evidence from fission track dating. *Earth Planet. Sci. Lett.* 179, 437–451.
- PATEL, R.C. 1999: Structure of the Higher Himalayan Crystallines along the Suru-Doda Valleys (Zaskar), NW Himalaya. *Gondwana Research group Memoir* 6, 91–110.
- JHINGRAN, A.G., KOHLI, G. & SHUKLA, B.N. 1952: Geological notes on the traverse to the Spiti-valley (Punjab). Jointly with 3<sup>rd</sup> Royal Danish Expedition to Central Asia 1950. *Geol. Surv. India* (unpublished report).
- JOHNSON, G.D., OPDYKE, N.D., TANDON, S.K. AND NANDA, A.C. 1983: The magnetic polarity stratigraphy of the Siwalik group at Haritalyangar (India) and a new last appearance datum for *Ramapithecus* and *Sivapithecus* in Asia. *Paleogeography, Palaeoclimatology, Palaeoecology* 44, 223–249.
- JOHNSON, M.R.W. 2002: Shortening budgets and the role of continental subduction during India-Asia collision. *Earth-Science Reviews* 59, 101–123.
- KAKAR, R.K. 1988: Geology and tectonic setting of Central Crystalline rocks of Southern part of Higher Himachal Himalaya. *J. Geol. Soc. India* 31, 243–250.
- KANWAR, S.S. & AHLUWALIA, A.D. 1979: Lithostratigraphy of Upper Paleozoic tethyan sequence in Chandra Valley near Bara Lacha La, district Lahul and Spiti, Himachal Pradesh, India. *Contr. Himalayan Geol. (Delhi)* 1, 147–153.
- KAPOOR, H.M. 1977: Lower Gondwana of Nishadbagh, Kashmir and its significance. *Geophytology* 7, 188–196.
- KARUNKARAN, C. AND RANGA RAO, A. 1976: State of exploration for hydrocarbons in the Himalayan region. *Contributions to stratigraphy and structure*. New Delhi Himalayan Geology Seminar, 1–72.
- KLÖTZLI, U.S. 1997: Zircon evaporation TIMS: Method and procedures. *Analyst* 122, 1239–1248.
- KLOOTWIJK, C.T., CONAGHAN, P.J. & POWL, C. MCA. 1985: The Himalayan arc, oroclinal bending and back-arc spreading. *Earth Planet. Sci. Lett.* 75, 167–183.
- GEE, J., PEIRCE, J., SMITH, G. & MCFADDEN, P. 1992: An early India-Asia contact: Paleomagnetic constraints from the Ninetyeast Ridge. *ODPLeg* 121. *Geology* 20, 395–398.
- KOBER, B. 1987: Single-zircon evaporation combined with Pb + emitter bedding for <sup>207</sup>Pb/<sup>206</sup>Pb-age investigations using thermal ion mass spectrometry, and applications to zirconology. *Contrib. Mineral. Petrol.* 96, 63–71.
- KOHLSTEDT, D.L., EVANS, B. & MACKWELL, S.J. 1995: Strength of lithosphere: Constraints imposed by laboratory experiments. *J. Geophys. Res.* 100, 17587–17602.
- KÜNDIG, R. 1989: Domal structures and High grade metamorphism in the Higher Himalayan Crystalline, Zaskar region, north-west Himalaya, India. *Journal of metamorphic Geology* 7, 43–55.
- KUMAR, G., JOSHI, A. & MATHUR, V.K. 1987: Redlichid trilobites from the Tal Formation, Lesser Himalaya, India. *Curr. Sci.* 56, 659–663.
- LAL, N., JAIN, A.K. & SORKHABI, R.B. 1995: Late Cenozoic-Quaternary Thermo-Tectonic history of Higher Himalayan Crystalline (HHC) in Kishtwar-Padar-Zaskar region, NW Himalaya: Evidence from fission track ages. *J. Geol. Soc. India* 45, 375–391.
- RAINA, B.K., BHARGAVA, O.N., MAITHY, P.K. & BABU, R. 1984: The Precambrian-Cambrian boundary problem and its prospects, Northwest Himalaya, India. *Geol. Mag.* 121, 211–216.
- KWATRA, S.K., BHANOT, V.B., KAKAR, R.K., KANSAL, A.K. 1986: Rb-Sr radiometric ages of the Wangtu Gneissic Complex, Kinaur district, Higher Himachal Himalaya. *Bull. Indian Geol. Assoc.* 19, 127–130.
- LAL, N., MEHTA, Y.P., KUMAR, D., KUMAR, A. & JAIN, A.K. 1999: Cooling and exhumation history of the Mandi granite and adjoining tectonic units, Himachal Pradesh, and estimation of closure temperature from external surface zircon. *Gondwana Res. Group Mem.* 6, 207–216.
- LANGE, R.L. & CARMICHAEL, I.S.E. 1990: Thermodynamic properties of silicate liquids with emphases on density, thermal expansion and compressibility. In: NICHOLS, J. & RISSEL, J.K. (Ed.): *Modern methods of igneous petrology: Understanding magmatic processes*. *Reviews in mineralogy* 24, *Miner. Soc. America*, 25–64.
- LARROQUE, C., CALASSOU, S., MALAVIEILLE, J. AND CHANIER, F. 1995: Experimental modelling of forearc basin development during accretionary wedge growth. *Basin Research* 7, 255–268.
- LE FORT, P. 1975: Himalayas: the collided range. Present knowledge of the continental arc. *Amer. J. Sci.* 275A, 1–44.
- 1986: Metamorphism and magmatism during the Himalayan collision. In: COWARD, M.P. & RIES, A.C. (Eds): *Collision tectonics*. *Geol. Soc. Spec. Publ. (London)* 19, 152–172.
- 1997: Evolution of the Himalaya. In A. Yin & T.M. Harrison (Eds.), *The Tectonic Evolution of Asia*. P. 95–109.
- DEBON, F., PÉCHER, A., SONET, J., VIDAL, P. 1986: The 500 Ma magmatic event in Alpine sothern Asia, a thermal episode at Gondwana scale, *Sciences de la Terre. Mémoire (Nancy)* 47, 191–209.
- LYDEKKER, R. 1878: *Geology of Kashmir, Kishtwar and Panghi*. *Rec. geol. Surv. India* 11, 31–64.
- 1883: The geology of Kashmir and Chamba territories and the British district of Khagan. *Mem. geol. Surv. India* 22, 344 pp.
- LYON-CAEN, H. & MOLNAR, P. 1985: Gravity anomalies, Flexure of the Indian plate, and the structure, support and evolution of the Himalaya and Ganga basin. *Tectonics*, 4/6, 513–538.
- MACFARLANE, A.M. 1993: Chronology of the tectonic events in the crystalline core of the Himalaya, Langtang National Park, Central Nepal. *Tectonics* 12, 1004–1025.
- MAHÉO, G., BERTRAND, H., GUILLOT, S., MASCLE G., PÉCHER, A., PICARD, C. & DE SIGOYER, J. 2000: Témoind d'un arc immature téthysien dans les ophiolites du Sud Ladakh (NW Himalaya, Inde). *C.R. Acad. Sci. (Paris), Earth and Planet. Sci.* 330, 289–295.
- MALAVIEILLE, J., LARROQUE, C. & CALASSOU, S. 1993: Modélisation expérimentale des relations tectoniques/sédimentation entre bassin avant-arc et prism d'accrétion. *C.R. Acad. Sci. (Paris)* 316, 1131–1137.
- MAKOVSKY, Y., KLEMPERER, S.L., LIYAN, H. & DEYUAN, L. 1996: Structural elements of the southern Tethyan Himalaya crust from wide-angle seismic data. *Tectonics*, 15/5, 997–1005.
- MANICKAVASAGAM, R.M., JAIN, A.K., SINGH, S. & ASOKAN, A. 1999: Metamorphic evolution of the northwest Himalaya, India: Pressure-temperature data, inverted metamorphism, and exhumation in the Kashmir, Himachal, and Garhwal Himalayas. *Geol. Soc. America Spec. Paper* 328, 179–198.
- MARGERIE, DE E. & HEIM ALBERT, 1888: Les dislocations de l'écorce terrestre. *J. Wurster, Zürich*.
- MARQUER, D., CHAWLA, H.S., CHALANDES, N. 2000: Pre-alpine high grade metamorphism in the High Himalaya. *Eclogae gel. Helv.* 93, 207–220.
- MASCLE, G.H. 1985: L'Himalaya résulte-t-il du télescopage de trois chaînes? *Bull. Soc. géol. France* 8, t.I. 3, 289–304.
- HÉRAIL, G., VAN HAVER, T. & DELCAILLAU, B. 1986: Structure et évolution des bassins d'épissure et de périssure liés à la chaîne Himalayenne. *BCREDP* 10, 181–203.
- MASSONE, H.J. 1995: Experimental and petrogenetic study of UHPM. In COLEMAN, R.G. & WANG, X. (Ed.): *Ultrahigh pressure metamorphism*, Cambridge University Press, 33–95.
- MATHUR, N.S. 1978: Biostratigraphical aspects of the Subathu Formation, Kumaun Himalaya. In *Recent Researches in Geology*, Hindustan Publishing Corp. (India), Delhi, 5, 95–112.
- MATHUR, A.K., MISHRA, V.P. & MEHRA, S. 1996: Systematic study of plant fossils from Dagshai, Kasauli and Dharamsala Formations of Himachal Pradesh, Paleont. *Indica*, N.S. 50, 1–121.

- MATTE, P., TAPPONNIER, P., ARNAUD, N., BOURJOT, L., AVOUAC, J.P., VIDAL, P., QING, L., YUSHENG, P. & YI, W. 1996: Tectonics of Western Tibet, between the Tarim and the Indus. *Earth planet. Sci Lett.* 142, 311–330.
- MC ELHINNY, M.W. 1979: *The earth: its origin, structure and evolution.* Academic press, London.
- MC ELROY, R., CATER, J., ROBERTS, I., PECKHAM, A. & BOND, M. 1990: The structure and stratigraphy of SE Zaskar, Ladakh Himalaya. *J. geol. Soc. (London)*, 147, 989–997.
- MC KENZIE, D.P. & SCLATER, J.C. 1971: The evolution of the Indian Ocean since the Late Cretaceous. *Geophys. J. r. astron. Soc.* 24, 437–528.
- MEDLICOTT, H.B. 1864: On the geological structure and relations of the southern portion of the Himalayan range between the rivers Ganges and Ravee. *Mem. Geol. Surv. India.* III, 2, 1–206.
- MEIGS, A.J., BURBANK, D.W., AND BECK, R.A. 1995: Middle-late Miocene (>10Ma) formation of the Main Boundary thrust in the western Himalaya. *Geology* 23, 423–426.
- MEHTA, P.K. 1977: Rb/Sr geochronology of the Kulu-Mandi belt: its implication for the Himalayan tectogenesis. *Geol. Rdsch.* 66, 156–175.
- 1978: Rb/Sr geochronology of the Kulu-Mandi belt: its implication for the Himalayan tectogenesis—a reply. *Geol. Rdsch.* 68, 383–392.
- MÉTIVIER, F., GAUDEMER, Y., TAPPONNIER, P. & KLEIN, M. 1999: Mass accumulation rates in Asia during the Cenozoic. *Geophys. J. Int.* 137, 280–318.
- MIDDLEMISS, C.S. 1887: Physical geology of West British Garhwal. *Rec. geol. Surv. India*, 20/1, 26–40.
- 1910: A revision of the Silurian-Triassic sequence in Kashmir. *Rec. geol. Surv. India* 40, 206–260.
- MILLER, C., KLÖTZLI, U., FRANK, W., THÖNI, M., GRASEMANN, B. 2000: Proterozoic crustal evolution in the NW Himalaya (India) as recorded by circa 1.80 Ga mafic and 1.84 Ga granitic magmatism. *Precambrian Res.* 103, 191–206.
- MISRA, D.K. 1993: Tectonic setting and deformational features in Satluj and Beas Valley of Himachal Pradesh. *Indian J. petrol. Geol.* 2, 81–92.
- GURURAJAN, N.S. 1994: The closure of Rampur window in Satluj Valley of Himachal Pradesh: Some new observations. *J. Himalayan Geol.* 5, 127–131.
- MOLNAR, P. 1990: A review of the seismicity and the rate of underthrusting and deformation at the Himalaya. *J. Himalayan geol.* 1, 131–154.
- ENGLAND, P. 1990: Late Cenozoic uplift of mountain ranges and global climate change: chicken or egg? *Nature (London)* 346, 29–34.
- LYON-CAEN, H. 1989: Fault plane solutions of earthquakes and active tectonics of the Tibetan plateau and its margins. *Geophys. J. Int.* 99, 123–153.
- TAPPONNIER, P. 1975: Cenozoic tectonics of Asia: effects of a continental collision. *Science* 189, 419–426.
- MUKHERJEE, B.K. & SACHAN, H.K. 2001: Discovery of coesite from Indian Himalaya: A record of ultra-high pressure metamorphism in Indian Continental Crust. *Current Science* 81, 1358–1361.
- MUKHOPADHYAY, D.K., BHADRA, B.K., GHOSH, T.K. AND SRIVASTAVA, D.C. 1997: Ductile shearing and large-scale thrusting in the Main Central Thrust Zone, Chur-Peak area, Lesser Himachal Himalaya. *J. geol. Soc. India*, 50, 5–24.
- MISHRA, P. 1999: A balanced cross section across the Himalayan foreland belt, the Punjab and Himachal foothills: A reinterpretation of structural styles and evolution. *Proc. Indian Acad. Sci. (Earth Planet. Sci.)*, 108, 189–205.
- NABHOLZ, W.K. & VOLL, G. 1963: Bau und Bewegung im gotthardmassivischen Mesozoikum bei Ilanz (Graubünden). *Eclogae geol. Helv.* 56, 755–808.
- NAHA, K. & RAY, S.K. 1971: Evidence of overthrusting in the metamorphic terrane of the Simla Himalayas. *Amer. J. Science* 270, 30–42.
- RAY, S.K. 1972: Structural evolution of the Simla klippe in the Lower Himalayas. *Geol. Rdsch.* 61, 1050–1086.
- NAJMAN, Y., CLIFT, P., JOHNSON, M.R.W. & ROBERTSON, A.H.F. 1993: Early stages of foreland basin evolution in the Lesser Himalaya, N India, in Treloar, P.J. & Searle, M.P., (eds.) *Himalayan tectonics.* Geol. Soc. London spec. Publ. 74, 541–558.
- BICKLE, M. AND CHAPMAN, H. 2000: Early Himalayan exhumation: Isotopic constraints from the Indian foreland basin. *Terra Nova*, 12, 28–34.
- GARZANTI, E. 2000: Reconstructing early Himalayan tectonic evolution and paleogeography from Tertiary foreland basin sedimentary rocks, northern India. *Geol. Soc. Amer. Bull.* 112, 435–449.
- PRINGLE, M., GODIN, L. & OLIVER, G. 2001: Dating of the oldest continental sediments from the Himalayan foreland basin. *Nature* 410, 194–197.
- NAKAZAWA, K. & KAPOOR, H.M. 1973: Spilitic pillow lava in Panjal Trap of Kashmir, India. *Memoires of the faculty of sciences, Kyoto University, Series of Geology and Mineralogy*, 39, 83–98.
- 1985: The Permian and Triassic systems in the Tethys—their paleogeography. In NAKAZAWA, K & DICKINS, J.M. (eds.) *The Tethys—her paleogeography and paleobiogeography from Paleozoic to Mesozoic.* Tokio, Tokai University Press, 93–111.
- KAPOOR, H.M., ISHI, K., BANDO, Y., OKIMURA, Y. & TOKUOKA, T. 1975: The Upper Permian Lower Triassic in Kashmir, India. *Mem. Faculty Sciences Kyoto University, Geology-Mineralogy* 42, 1–106.
- NANDA, M.M. & SINGH, M.P. 1977: Stratigraphy and sedimentation of the Zaskar area, Ladakh and adjoining parts of the Lahul region of Himachal Pradesh. *Himalayan Geol. (Dehra Dun)* 6, 365–388.
- NICORA, A., GAETANI, M. & GARZANTI, E. 1984: Late Permian to Anisian in Zaskar (Ladakh, Himalaya). *Rend. Soc. Geol. Ital.* 7, 27–30.
- NORTON, I.O. & SCLATER, J.G. 1979: A model for the evolution of the Indian Ocean and the breakup of Gondwanaland. *J. Geophys. Res.* 84/10, 6803–6830.
- OCHS III, F.A. & LANGE, R. A. 1999: The density of hydrous magmatic liquids. *Science* 283, 1314–1317.
- OKAYA, N., CLOETINGH, S. & MUELLER, S. 1996: A lithospheric cross-section through the Swiss Alps-II. Constraints on the mechanical structure of a continent-continent collision zone. *Geophys. J. Int.* 127, 399–414.
- OLDHAM, R.D. 1883: Note on the geology of Jaunsar and the Lower Himalayas. *Rec. Geol. Surv. India* 14, 193–198.
- 1888: The sequence and correlation of the Pre-Tertiary Sedimentary formations of the Simla region of the Lower Himalayas. *Rec. Geol. Surv. India* 21, 130–143.
- PACHAURI, A.K. 1972: Stratigraphy, correlation and tectonics of the area around Purola, Uttarkashi and Dehra Dun districts, U.P. *Himalayan Geol.* 2, 371–387.
- PANT, C.C. & SHUKLA, U.K. 1999: Nagthat Formation: An example of a progradational, tide-dominated Proterozoic succession in Kumaun Lesser Himalaya, India. *J. Asian Earth Sci.* 17, 353–368.
- PAREEK, H.S. 1983: The Himachal and Panjal Traps; a geochemical appraisal. In: SINHA, A.K. (ed.): *Contemporary Geoscientific researches in Himalaya (Dehra Dun)*, 2, 1–8.
- PARKASH, B., SHARMA, R.P. & ROY, A.K. 1980: The Siwalik Group (molasse): Sediments shed by collision of continental plates. *Sedimentary Geology* 25, 127–159. <
- PARRISH, R.R. & HODGES, K.V. 1996: Isotopic constraints on the age and provenance of the Lesser and Greater Himalayan sequences. *Nepalese Himalaya. Geol. Soc. Amer. Bull.* 108, 904–911.
- PATEL, R.C., SINGH, S., ASOKAN, A., MANICKAVASAGAM, R.M. & JAIN, A.K. 1993: Extensional tectonics in the Himalayan orogen. In: TRELOAR, P.J. & SEARLE, M.P. (eds), *Himalayan tectonics.* Geol. Soc. Spec. Publ. 74, 445–459.
- PATIÑO DOUCE & HARRIS, N. 1998: Experimental constraints on Himalayan Anatexis. *J. Petrol.* 39, 689–710.
- PATRIAT, P. & ACHACHE, J. 1984: India-Eurasia collision chronology has implications for crustal shortening and driving mechanism of plates. *Nature (London)* 311, 615–621.
- SEGOUFIN, J., SCHLICH, R., GOSLIN, J., AUZENDE, J.M., BEUZART, P., BONNIN, J. & OLIVET, J.L. 1982: Les mouvements relatifs de l'Inde, de l'Afrique et de l'Eurasie. *Bull. Soc. géol. France*, 24, 363–373.
- PAUL, S.K. & PAUL, R. 1999: Northeast-southwest extensional Tethyan Shear Zone within compressional regime of the Himalaya, Lahaul-Spiti, India. *Gondwana Research Group Memoir* 6, 135–144.
- PÉCHER, A. 1977: Geology of the Nepal Himalaya: deformation and petrography in the Main Central Thrust zone. *Colloq. int. CNRS n° 268*, 301–318.
- 1991: The contact between the higher Himalaya Crystallines and the Ti-

- betan sedimentary series: Miocene large-scale dextral shearing. *Tectonics*, 10, 587–598.
- LE FORT, P. 1989: Stretching lineation trajectories in the crystalline pile of central Nepal, 5th Himalaya-Tibet-Karakorum Workshop, Milano, Abstr. vol. p. 39.
- PIERCE, J. 1978: The northward motion of India since the Late Cretaceous. *Geophys. J. r Astron. Soc.* 52, 277–311.
- PILGRIM, G.E. & WEST, W.D. 1928: The structure and correlation of the Simla rocks. *Mem. Geol. Surv. India*, 53, 140pp.
- POGNANTE, U. & LOMBARDO, B. 1989: Metamorphic evolution of the High Himalayan Crystallines in SE Zaskar, India. *J. metamorph. Geol.* 7, 9–17.
- CASTELLI, D., BENNA, P., GENOVESE, G., OBERLI, F., MEIER, M. & TONARINI, S. 1990: The crystalline units of the High Himalayas in the Lahul-Zaskar region (northwest India): metamorphic-tectonic history and geochronology of the collided and imbricated Indian plate. *Geol. Mag.* 127, 191–116.
- POWERS, P.M., LILLIE, R.J. & YEATS, R.S. 1998: Structure and shortening of the Kangra and Dehra Dun reentrants, Sub-Himalaya, India. *Geol. Soc. Amer. Bull.* 110, 1010–1027.
- PRINCE, C., HARRIS, N. & VANCE, D. 2001: Fluid-enhanced melting during prograde metamorphism. *J. geol. Soc. London*, 158, 233–241.
- Qin, C. Papadimitriou, E.E., Pazachos, B.C. & Karakaisis, G.F. 2001: Time-dependent seismicity in China. *J. Asian Earth Sci.* 19, 97–128.
- RAGE, J.C., CAPPETTA, H. HARTENBERGER, J.L., JAEGER, J.J., SUDRE, J., VIANEYLAUD, M., KUMAR, K. PRASAD, G.V.R. & SAHNI, A. 1995: Collision age. *Nature (London)* 375, 286.
- RAINA, V.K. & BHATTACHARYYA, D.P. 1977: The Geology of part of the Chharap and Sarchu Valleys, Lahaul and Spiti District, Himachal Pradesh. Golden Jubilee Volume: Geol., Min. & Met. Soc. of India 1974, 129–142.
- RAIVERMAN, V., KUNTE, S.V. & MUKHERJEA, A. 1983: Basin Geometry, Cenozoic Sedimentation and Hydrocarbon Prospects in North Western Himalaya and Indo-Gangetic Plains. *Petroleum Asia J.* 6, 67–92.
- SRIVASTAVA, P. & PRASAD, D.N. 1993: On the Foothill Thrust of Northeastern Himalaya. *J. Himalayan Geol.* 4, 237–256.
- RAMESHWAR, R.D., SHARMA, K.K. & CHOUBEY, V.M. 1991: *J. Himalayan Geol.* 2, 39–46.
- RAMSAY, J.G. 1967: *Folding and Fracturing of rocks.* McGraw-Hill, New York.
- RANGA RAO, A., DHAR, C.L., RAVI, J., RAO, S.V. & SHAH, S.K. 1982: Contributions to the stratigraphy of Spiti. *Himalayan Geol.* 12, 98–113.
- AGARWAL, R.P., SHARMA, U.N., BHALLA, M.S., AND NANDA, A.C. 1988: Magnetic polarity stratigraphy and vertebrate palaeontology of Upper Siwalk Sub-group of Jammu Hills, India. *J. geol. Soc. India*, 31, 361–385.
- RATSCHBACHER, L., FRISCH, W. & GUANGHUA, L. 1994: Distributed deformation in southern and western Tibet during and after the India-Asia collision. *J. Geophys. Res.* 99, 19917–19945.
- RATTAN, S.S. 1973: Stratigraphy and sedimentation of the Chamba area Western Himachal Pradesh. *Himalayan Geol.* 3, 231–248.
- 1974: On the Manjir conglomerate of the Chamba area Western Himachal Pradesh. *Himalayan Geol.* 3, 231–248.
- 1978: Salooni Formation: The Permo-Carboniferous sequence of the Tethys Himalayan belt in the Chamba area., western Himachal Pradesh, India. *Recent Res. Geol.* 7, 322–338.
- 1985: Flysch sedimentation in the Chamba area, Himachal Pradesh. *Current Trends Geol.* 5, 43–54.
- REUBER, I. 1989: The Dras arc: two successive volcanic events on eroded oceanic crust. *Tectonophysics* 161, 93–106.
- COLCHEN, M. & MEVEL, C. 1987: The geodynamic evolution of the South-Tethyan margin in Zaskar, NW-Himalaya, as revealed by the Spongtag ophiolitic melanges. *Geodinamica Acta*, 1, 283–296.
- ROBYR, M. 2002: Thrusting, extension, and doming in the High Himalaya of Lahul-Zaskar area (NW India): structural and pressure-temperature constraints. *Mém. géol. Lausanne*, 40, 126 pp.
- VANNAY, J.-C., EPARD, J.-L. & STECK, A. 2002: Thrusting, extension, and doming during polyphase tectonometamorphic evolution of the High Himalayan Crystalline Zone in NW India. *J. Asian Earth Sci.* 21, 221–239.
- ROWLY, D.B. 1996: Age of initiation of collision between India and Asia: A review of stratigraphic data. *EPSL. Earth Planet. Sci. Lett.* 145, 1–13.
- SAKAI, H. 1983: Geology of the Tansen Group of the Lesser Himalaya in Nepal. *Memoir of the Faculty of Sciences, Kyushu University, Series D.* 5, 27–74.
- SAKLANI, P.S. 1993: *Geology of the Lower Himalaya (Garhwal).* Internat. Books and Periodicals supply Service, Delhi, 246pp.
- SCHÄRER, U., HAMET, J.U. & ALLEGRE, C.J. 1984: The Transhimalaya (gangdes) plutonism in the Ladakh region: a U-Pb and Rb-Sr study. *Earth and Planetary Science Letters*, 67, 327–339.
- SCHILL, E. APPEL, E., ZEH, O., SINGH, V.K. & GAUTAM, P. 2001: Coupling of late-orogenic tectonics and secondary pyrrhotite remanences: towards a separation of different rotation processes and quantification of rotational underthrusting in the western Himalaya (northern India). *Tectonophysics* 337, 1–26.
- SCHLUP, M. 2003: Exhumation history of the western Himalaya: The Rupshu-Lahul-Kullu geochronological transect (NW India). Ph.D thesis, University of Lausanne, 173pp.
- CARTER, A., COSCA, M. AND STECK, A. 2003: Exhumation history of eastern Ladakh revealed by  $^{40}\text{Ar}/^{39}\text{Ar}$  and fission track ages: The Indus river-Tso Morarti transect, NW Himalaya. *J. geol. Soc. London*, 160, 1–15.
- SCOTESE, C.R., GAHAGAN, L.M. & LARSON, R.L. 1988: Plate tectonic reconstructions of the Cretaceous and Cenozoic ocean basins. *Tectonophysics*, 155, 27–48.
- SEARLE, M.P. 1983: Stratigraphy, structure and evolution of the Tibetan Tethys zone in Zaskar and the Indus suture zone in the Ladakh Himalaya. *Royal Soc. Edinburgh Transactions, Earth Sci.* 73, 203–217.
- SEARLE, M.P. 1986: Structural evolution and sequence of thrusting in the High Himalayan, Tibetan-Tethys and Indus suture zones of Zaskar and Ladakh, Western Himalaya. *J. struct. Geol.* 8, 923–936.
- COOPER, D.J.W. & REX, A.J. 1988: Collision tectonics of the Ladakh-Zaskar Himalaya. In: SHACKLETON, R.M., DEWEY, J.F. & WINDLEY, B.F. (eds.): *Tectonic evolution of the Himalayas and Tibet.* London Royal Soc. 117–149.
- REX, A.J. 1989: Thermal model for the Zaskar Himalaya. *J. metam. Geol.* 7, 127–134.
- WARTERS, D.J., REX, D.C. & WILSON, R.N. 1992: Pressure, temperature and time constraints on Himalayan metamorphism from eastern Kashmir and western Zaskar. *Geol. Soc. London. J.* 149, 753–773.
- WINDLEY, B.F., COWARD, M.P., COOPER, D.J.W., REX, A.J., REX, D., TINDONG, L., XUCHANG, X., JAN, M.Q., THAKUR, V.C. & KUMAR, S. 1987: The closing of Tethys and the tectonics of the Himalaya. *Bull. geol. Soc. Amer.* 98, 678–701.
- CORFIELD, R.I., STEPENSON, B. & MCCARRON, J. 1997: Structure of the North Indian continental margin in the Ladakh-Zaskar Himalayas: implications for the timing of obduction of the Spongtag ophiolite, India-Asia collision and deformation events in the Himalaya. *Geol. Mag.* 134, 297–316.
- PICKERING, K.T. & COOPER, D.J.W. 1990: Restoration and evolution of the intermontane Indus molasse basin, Ladakh Himalaya, India. *Tectonophysics*, 174, 301–314.
- WATERS, D.J., DRANSFIELD, M.W., STEPHENSON, B.J., WALKER, C.B., WALKER, J.D. & REX, D.C. 1999: Thermal and mechanical models for the structural and metamorphic evolution of the Zaskar High Himalaya. In: MAC NICOLL, C. & RYAN, P.D. (eds.) *Continental tectonics.* Geol. Soc. London, spec. Publ. 164, 139–156.
- SEEBER, L. & GORNITZ, V. 1983: River profiles along the Himalayan Arc as indicators of active tectonics. *Tectonophysics* 92, 335–367.
- SHAH, I. 1977: Stratigraphy of Pakistan. *Geol. Survey of Pakistan Memoirs* 12, 138p.
- SHARMA, K.K. 1977: A contribution to the geology of the Sutluy Valley, Kinnaur, Himachal Pradesh, India. In *Colloques internationaux du C.N.R.S. No 268-Ecologie et géologie de l'Himalaya*, 369–379.
- SHARMA, V.P. & RASHID, S.A. 2001: Geochemical evolution of peraluminous paleoproterozoic bandal orthogneiss NW, Himalaya, Himachal Pradesh, India: implications for the ancient crustal growth in the Himalaya. *J. Asian Earth Sci.* 19, 413–428.



- SINCLAIR, H.D. & JAFFEY, N. 2001: Sedimentology of the Indus group, Ladakh, northern India: implications for the timing of initiation of the palaeo-Indus River. *J. geol. Soc. London* 158, 151–162.
- SINGH, K.P. 1979: Deformation history of the rocks around Sarahan Bushair, Himachal Pradesh. In: SAKLANI, P.S. (Ed.): *Structural Geology of the Himalaya*, 163–182.
- SINGH, K. 1991: Strain variation in the Berinag Thrust Sheet and its relationship with the Main Central Thrust in the Yamuna and Tons valleys, Garhwal Himalaya. *J. Himalayan Geol.* 2, 71–78.
- 1993: Reverse and oblique slip movement along the Chamba Thrust, Northwest Himalaya: Implications for tectonic evolution. *J. Himalayan Geol.* 4, 143–148.
- SINGH, M.P., NANDA, M.M. & SINHA, P.K. 1976: The Ralaking volcanics of the Zaskar Valley (Ladakh), its geological setting, petrography, petrochemistry and a comparative study with the Panjal volcanics of the NW Himalaya. *Geol. Surv. India Misc. Publ. (Calcutta)* 41, 218–228.
- SINGH, S. & JAIN, A.K. 1993: Deformational and strain patterns of the Jutogh Nappe along the Sulej Valley in Jeori-Wangtu region, Himachal Pradesh, India. *J. Himalayan Geol.* 4, 41–55.
- CLAESSON, S., JAIN, A.K., SJOBERG, H., GEE, D.G., MANICKAVASAGAM, R.M., ANDREASSON, P.G. 1994: Geochemistry of the Proterozoic peraluminous granitoids from the Higher Himalayan Crystalline (HHC) and Jutogh nappe, NW Himalaya, Himachal Pradesh, India. *J. Nepal Geol. Soc.* 10, 125.
- SINHA, A.K. 1981: Geology and tectonics of the Himalayan region of Ladakh, Himachal, Garhwal-Kumaun and Arunachal Pradesh: A review. In: ZAGROS-HINDU KUSH-HIMALAYA Geodynamic evolution. In: GUPTA, H.K. & DELAVY, F.M. (Ed.), *Geodynamics ser. 3*, 122–148.
- 1987: Tectonic zonation of the Central Himalaya and the crustal evolution of collision and compressional belts. *Tectonophysics* 134, 59–74.
- MISRA, D.K. & PAUL, S.K. 1997: Geology and Tectonic features of Kulu and Spiti-Lahaul sector of NW Himalaya. *Himalayan Geol.* 18, 1–15.
- SORKHABI, R.B., JAIN, A.K., TETSUMARU, I., FUKUI, S., LAL, N. & KUMAR, A. 1997: Cooling age record of domal uplift in the core of the Higher Himalayan Crystallines (HHC), southwest Zaskar, India. *Proc. Indian Acad. Sci. (earth Planet. Sci.)* 106, 169–179.
- SPRING, L. 1993: Structures gondwaniennes et himalayennes dans la zone tibétaine du Haut Lahul – Zaskar oriental. *Mém. géol. (Lausanne)* 14, 148p.
- CRESPO, A. 1992: Nappe tectonics, extension and metamorphic evolution in the Indian Tethys Himalaya. *Tectonics*, 11, 978–989.
- BUSSY, F., VANNAY, J.C., HUON, S. & COSCA, M. 1993a: Permo-Carboniferous “alkaline” granitic magmatism in the Indian High Himalaya (Upper Lahul – SE Zaskar): geochemical characterization and geotectonic implications. In: TRELOAR, P.J. & SEARLE, M.P. (eds.): *Himalayan tectonics*. *Geol. Soc. spec. Publ. (London)*, 74, 251–264.
- STUTZ, E., THÉLIN, P., MARCHANT, R., MASSON, H. & STECK, A. 1993b: Inverse metamorphic zonation in very low-grade Tibetan series of SE Zaskar and its tectonic consequences (Himalaya, NW India). *Schweiz. mineral. petrogr. Mitt.* 73, 85–96.
- SRIKANTIA, S.V. 1981: The lithostratigraphy, sedimentation and structure of Proterozoic-Phanerozoic formations of Spiti basin in the Higher Himalaya of Himachal Pradesh, India. In: SINHA, A.-K. (Ed.): *Contemporary geoscientific researches in Himalaya*. (Dehra Dun) 31–48.
- GANESAN, T.M., RAO, P.N., SINHA, P.K. & TIRKEY, B. 1980: Geology of Zaskar area, Ladakh Himalaya. *Himalayan Geol. (Dehra Dun)* 2, 1009–1033.
- BHARGAVA, O.N. 1982: An outline of the structure of the area between the Rohtang pass in Lahaul and the Indus Valley in Ladakh. *Geol. Surv. India, misc. Publ.* 41/3, 193–204, Calcutta.
- BHARGAVA, O.N. 1983: Geology of the Paleozoic sequence of the Kashmir Tethys Himalayan basin in the Lidder Valley, Jammu and Kashmir. *J. geol. Soc. India* 24, 363–377.
- BHARGAVA, O.N. 1998: Geology of Himachal Pradesh. *Geol. Soc. India (Bangalore)*, 406 pp.
- STÄUBLI, A. 1989: Polyphase deformation and the development of the Main Central Thrust (MCT) at the Kishtwar window, NW-India. *J. metamorphic Geol.* 7, 73–93.
- STAMPFLI, G.M., MOSAR, J., FAVRE, P., PILLUIT, A. & VANNAY, J.C. 2001: Permo-Mesozoic evolution of the western Tethys realm: the Neo-Tethys East Mediterranean Basin connection. In: P.A. ZIEGLER, W. CAVAZZA, A.H.F. ROBERTSON & S. CRASQUIN-SOLEAU (eds.), *Peri-Tethys Memoir 6: Peri-Tethyan Rift/Wrench basins and passive margins*. *Mém. Mus. Natn. Hist. Nat., Paris ISBN*, 186, 51–108.
- STECK, A. 1984: Structures de déformation tertiaires dans les Alpes centrales (transversale Aar-Simplon-Ossola). *Eclogae geol. Helv.* 77: 55–100.
- HUNZIKER, J. 1994: The Tertiary structural and thermal evolution of the Central Alps-compressional and extensional structures in an orogenic belt. *Tectonophysics* 238, 229–254.
- EPARD, J.L. & ROBYR, M. 1999: The NE-directed Shikar Beh Nappe: A major structure of the Higher Himalaya. *Eclogae geol. Helv.* 92, 239–250.
- SPRING, L., VANNAY, J.C., MASSON, H., BUCHER, H., STUTZ, E., MARCHANT, R. & TIÈCHE, J.-C. 1993: Geological transect across the North-western Himalaya Eastern Ladakh and Lahul (A model for the continental collision of India and Asia). *Eclogae geol. Helv.* 86, 219–263.
- EPARD, J.-L., VANNAY, J.-C., HUNZIKER, J., GIRARD, M., MORARD, A. & ROBYR, M. (1998): Geological transect across the Tso Morari and Spiti areas: The nappe structures of the Tethys Himalaya. *Eclogae geol. Helv.* 91, 103–121.
- EPARD, J.L., ESCHER, A., GOUFFON, Y. & MASSON, H. 2001: Carte géologique des Alpes de Suisse occidentale 1:100000. Carte géologique spéciale N°123, notice explicative. Office féd. Eaux Géologie (Berne), 73p.
- STEPHENSON, B.J., WATERS, D.J. & SEARLE, M.P. 2000: Inverted metamorphism and the main central thrust: Field relations and thermo-barometric constraints from the Kishtwar Window, NW Indian Himalaya. *J. metamorph. Geol.* 18, 571–590.
- SEARLE, M.P., WATERS, D.J. AND REX, D.C. 2001: Structure of the Main Central Thrust zone and extrusion of the High Himalayan deep crustal wedge, Kishtwar-Zaskar Himalaya. *J. Geol. Soc. London* 158, 637–652.
- STERN, R.J. 1994: Arc assembly and collision in the Neoproterozoic East African orogen. *Annual Review of Earth and Planetary Sciences*, 22, 319–351.
- STOLICZKA, F. 1865: Geological sections across the Himalayan Mountains. *Mem. geol. Surv. India (Calcutta)* 5, 1–154.
- STUTZ, E. A., 1988: Géologie de la chaîne de Nyimaling aux confins du Ladakh et du Rupshu (NW-Himalaya, Inde). *Mém. Géol. (Lausanne)* 3.
- STECK, A. 1986: La terminaison occidentale du Cristallin du Tso Morari (Haut-Himalaya; Ladakh méridional, Inde). *Eclog. geol. Helv.* 79, 253–269.
- SUTRE, E. 1990: Les formations de la marge Nord-Neotéthysienne et les mélanges ophiolitiques de la zone de suture de l’Indus en Himalaya du Ladakh, Inde. Thèse de doctorat Univ. Poitiers, (inédit).
- TANDON, S.K. 1991: The Himalayan Foreland: Focus on Siwalik Basin. In: *Sedimentary basins of India: Tectonic context*. Eds. S.K. TANDON, C.C. PANT, S.M. CASHYAP, 171–201.
- TAPPONNIER, P., PELTZER, G. & ARMJO, R. 1986: On the mechanics of collision between India and Asia. In: COWARD, M.P. & RIES, A.C. (eds), *Collision Tectonics*. *Geol. Soc. London, Spec. Publ.* 19, 115–157.
- THAKUR, V. C. 1983a: Deformation and metamorphism of the Tso Morari crystalline complex. In: THAKUR V.C. & SHARMA, K.K. (Eds.): *Geology of the Indus Suture Zone of Ladakh* (p. 1–8). – *Wadia Inst. of Himalayan Geol. (Dehra Dun)*.
- 1983b: Paleotectonic evolution of Indus-Tsangpo Suture Zone in Ladakh and southern Tibet. In: THAKUR V.C. & SHARMA, K.K. (Eds.): *Geology of the Indus Suture Zone of Ladakh*, *Wadia Inst. of Himalayan Geol. (Dehra Dun)*. 195–204.
- 1984: Tectonic framework of the Indus and Shayok suture zones in Eastern Ladakh, Northwest Himalaya. *Tectonophysics* 101, 207–220.
- & MISRA, D.K. 1984: Tectonic framework of the Indus and Shyok suture zones in Eastern Ladakh, Northwest Himalaya. *Tectonophysics* 101, 207–220.
- VIRDI, N.S. 1979: Lithostratigraphy, structural framework, deformation and metamorphism of the southeastern region of Ladakh, Kashmir Himalaya, India. *Himalayan Geol.* 9, 63–78.

- THÖHNI, M. 1977: Geology, structural evolution and metamorphic zoning in the Kulu Valley (Himachal Pradesh, Himalayas, India) with special reference to the reversed metamorphism. *Mitt. Ges. Geol. Bergbaustud. Österr.* 24, 125–187.
- THOMPSON, R.N., MORRISON, M.A., HENDRY, G.L. & PARRY, S.J. 1984: An assessment of the relative roles of crust and mantle in magma genesis: an elemental approach. *Phil. Trans. Roy. Soc. London A* 310, 549–590.
- TIWARI, A.P. 1984: Stromatolites and Precambrian and Lower Cambrian biostratigraphy of Lesser Himalaya, India. *Proc. 5<sup>th</sup> Ind. Geophytological Conf.*, Lucknow 1983, Spl. Publ. 71–79.
- GAUR, R.K. & AMETA, S.S. 1978: A note on the geology of a part of Kinnaur district, Himachal Pradesh. *Himalayan Geol.* 8, 574–582.
- TRIPATHI, C., JANGPANGI, B.S., BHATT, D.K., KUMAR, G. & RAINA, B.K. 1984: Early Cambrian brachiopods from « Upper Tal », Mussoorie Syncline, Dehradun District, U.P. *Geophytology*, 14, 221–227.
- TRIVEDI, J.R., KEWAL, K.S. & GOPALAN, K. 1986: Widespread caledonian magmatism in Himalaya and its tectonic significans. *Terra Cognita*, 6, 144.
- TROMMSDORFF, V., DIETRICH, V. & HONEGGER, K. 1987: The Indus Suture Zone: Paleotectonic and Igneous Evolution in the Ladakh-Himalayas. In: SCHAEER, J.-P. & RODGERS, J. (Ed.): *The anatomy of mountain ranges* (p. 261–275). -Princeton Univ. Press, Princeton New Jersey.
- TURCOTE, D.L. & SCHUBERT, G. 1982: Geodynamics – Applications of continuum physics to geological problems. John Wiley & Sons, New York.
- ULMER, P. & TROMMSDORFF, V. 1995: Serpentine stability to mantle depths and subduction-related magmatism. *Science* 268, 858–861.
- U.S. ARMY MAP SERVICE, 1962: India and Pakistan, 1:250000, Washington D.C. (USA).
- VALDIYA, K.S. 1980: Geology of Kumaun Lesser Himalaya. Dehra Dun, India, Wadia Institute of Himalayan Geology, 291p.
- 1995: Proterozoic sedimentation and Pan-African geodynamic development in the Himaléaya. *Precambrian Res.* 74, 35–55.
- VANCE, D. & HARRIS, N. 1999: Timing of prograde metamorphism in the Zaskar Himalaya. *Geology* 27, 395–398.
- VAN HAVER, T. 1985: Etude stratigraphique, sédimentologique et structural d'un bassin d'avant arc: exemple du bassin de l'Indus, Ladakh, Himalaya. Ph.D. Thesis, University of Grenoble.
- BASSOULET, J.P., BLONDEAU, A. & MASCLE, G. 1984: Les séries détritiques du bassin de l'Indus au Ladakh: nouvelles données stratigraphiques et structurales. *Riv. ital. Paleont. (Stratigr.)* 90, 87–102.
- BONHOME, M.G., MASCLE, G. & APRAHAMIAN, J. 1986: Analyse K/Ar de phyllites fines des formations détritiques de l'Indus au Ladakh (Inde). Mise en évidence de l'âge Eocène supérieur du métamorphisme. *C. R. Acad. Sci. (Paris) Serie II*, 302(6): 325–330.
- VAN HINTE, J.E. 1978: Geohistory analysis: applications of micropaleontology in exploration geology. *Bull. amer. Assoc. petroleum Geol.* 62, 201–222.
- VANNAY, J.C. 1993: Géologie des chaînes du Haut-Himalaya et du Pir Panjal au Haut Lahul (NW Himalaya, Inde): Paléogéographie et tectonique, *Mém. géol. (Lausanne)* 16, 1–148.
- GRASEMANN, B. 1998: Inverted metamorphism in the High Himalaya of Himachal Pradesh (NW India): phase equilibria versus thermobarometry. *Schweiz. Mineral. Petrogr. Mitt.* 78, 107–132.
- GRASEMANN, B. 2001: Himalayan inverted metamorphism and syn-convergence extension as a consequence of general shear extrusion. *Geol. Mag.* 138, 253–276.
- SHARP, Z.D. & GRASEMANN, B. 1999: Himalayan inverted metamorphism constrained by oxygen isotope thermometry. *Contrib. Mineral. Petrol.* 137, 90–101.
- SPRING, L. 1993: The geochemistry of the continental basalts within the Tethyan Himalaya of Lahul-Spiti and SE Zaskar (NW India). *Geol. Soc. spec. Publ. (London)* 74, 237–249.
- STECK, A. 1995: Tectonic evolution of the High Himalaya in Upper Lahul (NW Himalaya, India). *Tectonics* 14, 253–263.
- VIRDI, N.S. 1976: Stratigraphy and structure of the area around Nirath, Dist. Simla, Himachal Pradesh. In: JHINGRAN, A.G. & VERMA, P.K. (eds.): *Himalayan Geology* 6, 163–175.
- 1979: Status of the Chail Formation vis-a-vis Jutogh-Chail relationship in the Himachal Lesser Himalaya. *Himalayan Geol.* 9/1, 111–125.
- THAKUR, V.C. & AZMI, R.J. 1978: Discovery and Significance of Permian Microfossils in the Tso Morari Crystallines of Ladakh, J&K, India. *Himalayan Geol.* 8, 993–1000.
- VOGGENREITER, W., HÖTZEL, H. & MECHIE, J. 1988: Low-angle detachment origin for the Red Sea Rift System? *Tectonophysics* 150, 51–75.
- VON LOCZY, 1907: Beobachtungen im östlichen Himalaya (vom 8. Bis 28. Febr. 1878). *Földr. Közlem.* 35, 1–24.
- WADIA, D.N. 1934: The Cambrian – Trias sequence of North Western Kashmir (parts of Muzaffarabad and Barumula districts). *Rec. Geol. Surv. India* 69, 60–63.
- 1937: The Cretaceous volcanic series of Astor/Deosai, Kashmir, and its intrusions. *Rec. Geol. Soc. India* 72/2, 151–161.
- WALKER, J.D., MARTIN, M.W., BOWRING, S.A., SEARLE, M.P., WATERS, D.J. & HODGES, K.V. 1999: Metamorphism, melting and extension: age constraints from the High Himalayan slab of southeast Zaskar and northwest Lahaul. *J. Geol.* 107, 473–495.
- WEINBERG, R.F. & DUNLAP, W.J. 2000: Growth and Deformation of the Ladakh Batholith, Northwest Himalayas: Implications for Timing of Continental Collision and Origin of Calc-Alcaline Batholiths. *J. Geol.* 108, 303–320.
- WERNICKE, B. 1985: Uniform-sens normal simple shear of the continental lithosphere. *Canad. J. Earth Sci.* 22, 108–125.
- WEST, W.D. 1939: Structure of the Shali window near Simla. *Rec. Geol. Surv. India* 74, 133–163.
- WEST, R.M., HUTCHISON, J.H. & MUNTHE, J. 1991: Miocene vertebrates from the Siwalik Group, western Nepal. *J. of vertebrate Paleontology* 11, 108–129.
- WHITE, N.M., PRINGLE, M., GARZANTI, E., BICKLE, M., NAJAN, Y. CHAPMAN, H. & FRIEND, P. 2002: Constraints on the exhumation and erosion of the High Himalayan Slab, NW India, from foreland basin deposits. *Earth planet. Sci Lett.* 195, 29–44.
- WYNNE, A.B. 1878: On the geology of the Salt Range in Punjab. *Mem. geol. Surv. India* 14, 1–314.
- WYSS, M. 1999: Structural geology and metamorphism of the Spiti valley-eastern Lahul-Parvati valley area, Himachal Himalaya (India). Ph.-D. thesis, Lausanne, 183pp.
- 2000: Metamorphic evolution of the northern Himachal Himalaya: phase equilibria constraints and thermobarometry. *Schweiz. Mineral. Petrogr. Mitt.* 80, 317–350.
- HERMANN, J. & STECK, A. 1999: Structural and metamorphic evolution of the northern Himachal Himalaya, NW India (Spiti-eastern Lahul-Parvati valley traverse). *Eclogae geol. Helv.* 92, 3–44.
- Yin, A. & T.M. Harrison 2000: Geological evolution of the Himalayan Tibetan orogen. *Annu. Rev. Earth Planet. Sci.* 28, 211–280.

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