Miocene time. Thermobarometric data indicate that the presently exposed portion of the MCT developed at ~600°C and at a depth of ~27 km. These data suggest average unroofing rates of ~1.5 mm/a since the mid-Miocene. We have analysed hornblende, muscovite, biotite and K-feldspar from GH and LH metamorphic rocks using the $^{40}Ar/^{39}Ar$ technique in an effort to constrain the mid-Miocene to Recent cooling history of this region. The majority of samples yielded ages ranging from latest Miocene to late Pliocene. An age gradient rising from 5 to 10 Ma was obtained from a hornblende from the upper LH. Muscovite ages from the UH and LH range from 9.4 to 3.1 Ma; biotite ages range from 15 to 3.4 Ma. Broad consistancy between LH and UH mineral ages suggests that the hanging wall and foot wall of the MCT experienced similar cooling histories since mid-Miocene time. There is no clear relationship between elevation and the apparent ages of minerals from different samples, implying non-uniform uplift of the UH and LH. The hornblende age and closure temperature (450-500°C) indicate cooling at a rate of 65-150 °C/Ma in the Pliocene. Such rapid cooling could only be achieved by extremely rapid unroofing (average rates > 3mm/a) in response to significant tectonic movement during the Pliocene through Holocene. We interpret this rapid uplift late in the development of this part of the orogen as a consequence of movement of the lower GH and upper LH over a ramp structure in the underlying Pliocene Main Boundary Thrust.

№ 7861

TECTONIC EVOLUTION OF THE HIMALAYAS AND THE TIBETAN PLATEAU

COPELAND, Peter, KIDD, W.S.F., and HARRISON, T. Mark, Dept. of Geol. Sciences, State Univ. of New York at Albany, Albany, NY 12222.

Available thermochronologic (T-τ), sedimentologic, and structural data from the the Himalayas, the southern Tibetan plateau (TP), and Indian Ocean suggest that during the tectonic evolution of the Himalayas and the TP, mechanisms for the accomodation of convergence between India and Asia have varied significantly. These data are consistent with the following chronology: **40-21 Ma:** Collision begins, relatively low relief in Tibet. *Mechanism*: Tectonic escape of the TP to the east along large-scale strike-slip faults. *Evidence*: low uplift rates, spreading in the South China Sea, inferred offsets along numerous faults. **21-16 Ma:** Rapid uplift in southern Tibet and High Himalayas, E-W normal faulting. *Mechanisms*: movement on MCT and related faults, gravitational collapse. *Evidence*: structural studies in Himalaya, T-τ studies in Nepal and southern Tibet, Bengal Fan stratigraphy, ODP Leg 116. **16-7 Ma:** Locally variable uplift, highstanding topography. *Mechanism*: continued temporally and spatially variable thickening and shortening distributed throughout the TP with several kilometers of topographic relief. *Evidence*: T-τ studies in southern Tibet. **7-0 Ma:** N-S normal faulting, rapid uplift in central Nepal, thrusting in Indian Ocean, historic strike-slip faulting. *Mechanisms*: extension of the TP, distributed shortening between the MCT and MBT, continental escape, development of an incipient plate boundary between India and Australia. *Evidence*: dating of N-S normal faults on the TP, T-τ of the Tibetan slab in southern Nepal, seismic studies of the Indian Ocean crust, plate motion studies. Total erosion since 40 Ma at the southern margin of the TP has exceeded 25 km whereas erosion farther north has removed less than 10 km of material. Paleontologic and sedimentologic data are consistent with an increase in elevation of the TP of 1-2 km since ~5 Ma. The change over from escape to distributed shortening in the early Miocene appears to have been rapid. The TP appears to have achieved most of its crustal thickness and topographic relief during the interval 20-7 Ma by distributed shortening. The southern TP appears from the available data to have attained its maximum sustainable crustal thickness relative to the thinner surroundings between 7 and 4 Ma. Afterward, distributed shortening could not keep up with the convergence and numerous and varied mechanisms, including plate reorganization, have occured.

№ 20531

THE ZANSKAR SHEAR ZONE: NORTHEAST - SOUTHWEST EXTENSION WITHIN THE HIGHER HIMALAYAS (LADAKH, INDIA)

HERREN, Eveline, Geologisches Institut, ETH Zentrum, CH - 8092 Zürich, Switzerland *

A complete geological section through the northwestern Himalayas is well exposed in Ladakh, India. The collision between the Indian shield and the Tibetan platform caused large-scale intracrustal thrusting and piling up of the Himalayan nappes. This compressional event was accompanied by prograde regional metamorphism. The metamorphism ranges from low-grade (anchimetamorphism) in the Indus suture zone in the northeast to upper amphibolite grade in the Higher Himalaya tectonic unit in the southwest.

In the Zanskar area a well exposed and morphologically prominent shear zone, 2.25 to 6.75 km wide, can be followed from the northwest to the southeast for at least 80 km. In contrast to the main compressional tectonics, this shear zone indicates an extensional event within the Higher Himalaya tectonic unit. This Zanskar shear zone involves granitic rocks, leucogranites of Tertiary age, and various metasediments and, in general, separates the Late Precambrian - Early Cambrian sedimentary sequence (Phe Formation) from the underlying crystalline basement (Zanskar Crystalline unit). A normal sense of shear has been determinated using asymmetric macroscopic and microscopic structures such as pegmatite boudins, feldspar augen, and crystallographic fabrics. The metamorphic isograds are very close within this shear zone as a result of shear deformation; a gradual transition from upper amphibolite to lower greenschist facies occurs within 200 m. Movement in this zone occurred late in the metamorphic history under greenschist or lower metamorphic conditions. The minimum horizontal extension and vertical displacement are on the order of 16 km and 19 km, respectively.

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№ 8334

REGIONAL TECTONIC FRAMEWORK AND EVOLUTION OF THE NANGA PARBAT REGION, PAKISTAN HIMALAYAS.

BUTLER, Robert W.H., Dept. of Earth Sciences, The Open University, Walton Hall, Milton Keynes, MK76AA, UK. OWEN, Lewis A., Depts. of Geography and Geology. Leicester University, LE17RH, UK. PRIOR, David J., Dept. of Earth Sciences, Leeds University, LS29JT, UK.

The Nanga Parbat basement Massif (NPM) was subducted under the Kohistan Arc Complex, along the Main Mantle Thrust (MMT) at about 50ma. However, the present crustal geometry results from the recent uplift of the NPM which has folded the MMT to form the Nanga Parbat Syntaxis.

The NPM comprises orthogneisses and metasediments. Field relations clearly indicate that metamorphic growth and complex deformational events predated collisional fabrics. A sequence of amphibolite facies metasediments, with a simple deformational history, are found along the MMT. These are interpreted as a cover sequence to the NPM and preserve Tertiary, collisional metamorphic and deformational events indicative of the subduction of NPM under the KA.

The recent rapid uplift of the NPM has been accommodated on a major shear zone which folds the MMT to its present vertical attitude. Ductile shearing thrusts the NPM NW over the KA and is superposed by cataclastic faults indicative of the cooling during uplift.

At the highest level NPM gneisses are thrust seismically over Quaternary Indus sediments. Field relations have allowed construction of a palaeoseismic map. Thrust faults are postdated by a dextral strike-slip system in which the locus of activity has migrated south with time. Seismicity indicates that this system is currently active south of the NPM around the Hazara Syntaxis.

№ 14552

COLLISION TECTONICS IN THE WESTERN HIMALAYAS: SUTURE ZONE P-T-t PATHS.

BARNICOAT, Andrew C., Dept. of Geology, UCW, Aberystwyth SY23 4PA, U.K. TRELOAR, Peter, J., Dept. of Geology, Imperial College, London SW7 2BP

The MMT zone marks the suture between the Indian plate and the Kohistan arc, formed as a result of collision at ca.50 Ma. Subsequent events have deformed and reorientated the MMT in the region of Nanga Parbat. Early in the collision event, orthogneisses and cover sediments of the Indian Plate were inter-sliced and folded with metbasites of the Kohistan arc under amphibolite facies conditions. Bi-gt-plg-ky-rut-ilm assemblages in metapelites allow thermobarometry of the suture zone to be performed; together with a transition from ilmenite to rutile as dominant Ti inclusion phase ingtpoints to an up-pressure prograde path terminating at ca. 10kb. Linear fabrics and sense of shear indicators record southerly overthrusting of the arc synchronous with this deep crustal metamorphism.

Continuing deformation lead to the formation of shear bands, shear zones, thrusts and oblique slip faults at progressively lower pressures and temperatures. These structures, which have enabled the uplift of the Indian plate to form the Nanga Parbat massif, are marked successively by bi-gt, bi and chl-bearing assemblages. Ar-Ar dates from muscovites and biotites are in the range 5-10Ma, compatible with existing fission-track ages of 1-3Ma. This corresponds to uplift rates of at least 1km Ma^{-1} over the past 10Ma. This uplift is currently occurring on the Liachar thrust which places amphibolite facies orthogneisses of the Indian plate over recent sediments of the river Indus.

№ 8336

COLLISION TECTONICS IN THE WESTERN HIMALAYAS : DEFORMATION MECHANISM PATHS.

KNIPE, R.J., Dept. of Earth Sciences, The University, Leeds, LS2 9JT, UK.

The junction between the Indian Plate and the Kohistan Arc in the Nanga Parbat area of NW Pakistan provides an ideal location for the study of deformation mechanisms during collision and uplift. Fault zones which were active at different times and under different conditions during the collision have been identified. The microstructures preserved on these faults are described and integrated into a synthesis of deformation mechanisms, conditions and kinematics which allows identification of uplift processes and histories in this area. A three stage history can be recognised: PHASE 1: An early deformation and cooling [ca 50Ma] of the Kohistan Arc associated with the overthrusting to the SSE achieved by crystal plastic deformation at amphibolite grade in a localised shear zone [The MMT] and accompanied by a progressive change towards unstable ductile flow. PHASE 2: Uplift without major deformation associated with the propagation of new thrusts

8 **E. G. Bombolakis***: THRUST FAULT MECHANICS AND DYNAMICS DURING A STAGE OF THRUST SHEET EMPLACEMENT [002051] .... 9:45 A

9 **Donald A. Medwedeff***: A NATURAL FRICTIONAL STRENGTH TEST AND THE MECHANICS OF THRUST WEDGES [024520] .... 10:00 A

10 **Nancye H. Dawers*, Leonardo Seeber**: THE DOBBS FERRY FAULT ZONE, N.Y.: ONE IN A SET OF POTENTIALLY SEISMOGENIC FAULTS OF THE MANHATTAN PRONG? [001182] .... 10:15 A

11 **Van S. Mount***: STATE OF STRESS NEAR MAJOR STRIKE-SLIP FAULTS [026484] .... 10:30 A

12 **Katherine M. Hansen*, Van S. Mount**: STATISTICAL COMPUTATION OF STRESS FIELDS IN THE EARTH'S CRUST [026482] .... 10:45 A

13 **Jerry F. Magloughlin***: A FOSSIL STRESS FIELD (?) IN A PSEUDOTACHYLITE FROM THE NASON TERRANE, NORTH CASCADE MOUNTAINS, WASHINGTON [016246] .... 11:00 A

14 **Kerri L. Nelson, Charles A. Wood***: ARC SEGMENTATION AND THE TERTIARY CALDERA FIELDS OF THE SOUTHWESTERN CORDILLERA [012399] .... 11:15 A

15 **Edward I. Erlich***: TIMING OF POST-EOCENE VOLCANISM IN TRANSVERSE STRUCTURES IN NORTHERN CIRCUM-PACIFIC [027706] .... 11:30 A

16 **Kevin Mallin*, William K. Hart**: MAGMATISM ASSOCIATED WITH CASCADE SEGMENTATION AND BASIN AND RANGE EXTENSION, NORTHEASTERN CALIFORNIA AND SOUTH-CENTRAL OREGON [015867] .... 11:45 A

TECTONICS VI: HIMALAYAN, ASIAN, AND SOUTHWESTERN PACIFIC TECTONICS

Majestic Ballroom, Radisson, 8:00 A.M.

Peter Coney and Peter Copeland, Presiding

1 **B. C. Burchfiel*, K. V. Hodges, L. H. Royden, Z. Chen, C. Deng, Y. Liu**: EXTENSION PARALLEL TO AND CONTEMPORANEOUS WITH COMPRESSION IN THE HIGH HIMALAYA, SOUTHERN TIBET [024670] .... 8:00 A

2 **Peter Copeland*, T. Mark Harrison, Patrick LeFort**: COOLING HISTORY OF THE MANASLU GRANITE, NORTH-CENTRAL NEPAL [007859] .... 8:15 A

3 **Peter Copeland, Kip V. Hodges*, T. Mark Harrison, P. LeFort, A. Pecher**: RAPID PLIOCENE UPLIFT ASSOCIATED WITH THE MAIN BOUNDARY THRUST, CENTRAL NEPAL [007858] .... 8:30 A

4 **Peter Copeland, W. S. F. Kidd*, T. Mark Harrison**: TECTONIC EVOLUTION OF THE HIMALAYAS AND THE TIBETAN PLATEAU [007861] .... 8:45 A

5 **Eveline Herren***: THE ZANSKAR SHEAR ZONE: NORTHEAST-SOUTHWEST EXTENSION WITHIN THE HIGHER HIMALAYAS (LADAKH, INDIA) [020531] .... 9:00 A

6 **Robert W. H. Butler*, Lewis A. Owen, David J. Prior**: REGIONAL TECTONIC FRAMEWORK AND EVOLUTION OF THE NANGA PARBAT REGION, PAKISTAN HIMALAYAS [008334] .... 9:15 A

7 **Andrew C. Barnicoat*, Peter J. Treloar**: COLLISION TECTONICS IN THE WESTERN HIMALAYAS: SUTURE ZONE P-T-t PATHS [014552] .... 9:30 A

8 **R. J. Knipe***: COLLISION TECTONICS IN THE WESTERN HIMALAYAS: DEFORMATION MECHANISM PATHS [008336] .... 9:45 A

9 **Peter J. Treloar*, Michael P. Coward, Mathew P. Williams, David C. Rex**: COLLISION PROCESSES IN THE NW HIMALAYAS: DEFORMATION, METAMORPHISM AND P-T-t PATHS IN THE NORTH INDIAN PLATE [021670] .... 10:00 A

10 **Peter K. Zeitler***: ION MICROPROBE DATING OF ZIRCON FROM THE MALAKAND GRANITE, NW HIMALAYA, PAKISTAN: A CONSTRAINT ON THE TIMING OF TERTIARY METAMORHPISM IN THE REGION [007349] .... 10:15 A

11 **P. F. Cerveny*, C. W. Naeser, P. B. Keleman, J. E. Lieberman, P. K. Zeitler**: ZIRCON FISSION-TRACK AGES FROM THE GASHERBRUM DIORITE, KARAKORAM RANGE, NORTHERN PAKISTAN [025164] .... 10:30 A

12 **James W. McDougall***: DECOLLEMENT THRUSTING AND FOLDING SOUTH OF THE MAIN BOUNDARY THRUST AND WEST OF THE INDUS RIVER, N. PAKISTAN [023663] .... 10:45 A

13 **M. S. Hendrix*, Z. Xiao, Y. Liang, S. A. Graham, A. R. Carroll, C. McKnight**: SANDSTONE PROVENANCE STUDIES, NORTH TARIM, SOUTH JUNGGAR, AND TURPAN BASINS, XINJIANG, CHINA [016860] .... 11:00 A

14 **Gregory A. Davis*, Yadong Zheng**: A POSSIBLE CORDILLERAN-TYPE METAMORPHIC CORE COMPLEX BENEATH THE GREAT WALL NEAR HEFANGKOU, HUAIROU COUNTY, NORTHERN CHINA [024757] .... 11:15 A

15 **D. L. Kimbrough*, A. J. Tulloch**: METAMORPHIC CORE COMPLEX IN WESTERN NEW ZEALAND RELATED TO THE LATE CRETACEOUS BREAKUP OF GONDWANA [023953] .... 11:30 A

16 **Peter J. Coney***: THE TASMAN OROGEN OF AUSTRALIA: SOMETHING DIFFERENT FROM DOWN UNDER [026861] .... 11:45 A

THEME SESSION 3: GEOPHYSICAL PATTERNS IN NORTH AMERICA

Theater, DCC, 8:00 A.M.

James G. Tanner and John A. Grow, Presiding

1 **R. E. Sweeney*, T. G. Hildenbrand, R. H. Godson, R. K. McConnell, W. F. Hanna, J. G. Tanner**: PROCEDURES FOR ASSEMBLY OF THE NORTH AMERICAN GRAVITY ANOMALY MAP AND DIGITAL GRIDDED DATA BASE [024942] .... 8:00 A

2 **D. J. Teskey*, R. H. Godson, S. D. Dods, P. J. Hood**: COMPILATION OF MAGNETIC ANOMALY MAP OF NORTH AMERICA [025075] .... 8:15 A

3 **Carlos L. V. Aiken*, Valerie Godley, Turgut Ozdenvar, Eric Madtson, Steve Tichner**: BOUGUER GRAVITY ANOMALIES OF SOUTH AMERICA AND TRANSCONTINENTAL GRAVITY MODELS [024934] .... 8:30 A

4 **M. F. de la Fuente*, Carlos L. V. Aiken, Robert W. Schellhorn, Manuel Mena**: GRAVITY ANOMALIES AND STRUCTURE OF MEXICO [024926] .... 8:45 A

5 **R. W. Simpson*, T. G. Hildenbrand, R. C. Jachens, D. F. Barnes**: GEOLOGIC IMPLICATIONS OF A NEW ISOSTATIC RESIDUAL GRAVITY MAP OF NORTH AMERICA [026991] .... 9:00 A

6 **Richard J. Blakely*, Andrew Griscom**: GEOLOGIC INSIGHTS FROM UPWARD CONTINUATION AND BOUNDARY ANALYSIS OF NORTH AMERICAN MAGNETIC AND GRAVITY MAPS [025633] .... 9:15 A

7 **Martin F. Kane***: GRAVITY EVIDENCE OF PLATE-COLLISION EFFECTS IN THE CONTINENTAL INTERIOR [026362] .... 9:30 A

8 **T. Feininger*, B. Loncarevic, D. Lefebvre**: THE SEPT-ILES LAYERED MAFIC INTRUSION: ITS GEOPHYSICAL EXPRESSION [021995] .... 9:45 A

9 **Leslie J. Kornik***: SUBDIVISIONS OF THE CANADIAN SHIELD: AN AEROMAGNETIC APPROACH [025098] .... 10:00 A

10 **G. M. Ross*, M. E. Villeneuve, R. R. Parrish, S. A. Bowring**: TECTONIC ASSEMBLY OF THE CANADIAN SHIELD IN THE ALBERTA SUBSURFACE: INTEGRATED POTENTIAL FIELD MAPPING AND U/Pb GEOCHRONOLOGY [008830] .... 10:15 A

11 **L. J. Kornik, M. D. Thomas***: GRAVITY & MAGNETIC SIGNATURES OF THE TRANS-HUDSON OROGEN: SIGNIFICANCE FOR STRUCTURE AND TECTONIC DEVELOPMENT [025099] .... 10:30 A

12 **Edward G. Lidiak*, William J. Hinze**: GEOPHYSICAL ANOMALY PATTERNS AS A GUIDE TO THE EXTENSION OF THE GRENVILLE PROVINCE IN THE SUBSURFACE OF EASTERN NORTH AMERICA [001878] .... 10:45 A

13 **Ali A. Nowroozi***: SEISMICITY PATTERNS OF THE SOUTHEASTERN UNITED STATES [003545] .... 11:00 A

14 **J. H. McBride***: APPALACHIAN GRAVITY GRADIENT AND BRUNSWICK ANOMALY--EVIDENCE FOR PALEOZOIC TERRANE BOUNDARIES OR MESOZOIC RIFTING? CONSTRAINTS FROM DEEP SEISMIC REFLECTION PROFILING [026094] .... 11:15 A

15 **V. J. S. Grauch***: STATISTICAL EVALUATION OF LINEAR TRENDS IN A COMPILATION OF AEROMAGNETIC DATA FROM THE SOUTHWESTERN U.S. [021654] .... 11:30 A

16 **L. W. Sobczak*, J. F. Halpenny**: SIGNIFICANCE OF GRAVITY ANOMALY MAPS FOR GEOLOGICAL STUDIES USING THE ARCTIC AS AN EXAMPLE [025095] .... 11:45 A

THEME SESSION 4: GLOBAL ASPECTS OF SEDIMENTARY GEOLOGY

3AFBE, DCC, 8:00 A.M.

Paul F. Ciesielski and Robert Ginsburg, Presiding

1 **Michelle A. Kominz*, Gerard C. Bond**: A NEW TECHNIQUE FOR DETERMINING TIME IN CYCLIC SEDIMENTS - APPLICATION TO THE NEWARK SUPERGROUP [005459] .... 8:00 A

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