of the AVF, and throughout the overlying Ordovician Lignite Limestone there are multiple high-angle reverse faults. The Transverse mountain system, which is connected to the regional displacement accommodated by D2-D4 structures is unknown but thought to be significant.

09:00 AM Ryerson, F. J.

THE NEOGINE THRUST, UPLIFT AND DEDUNATION HISTORY OF SOUTHERN TIBET

A growing body of evidence links changes in local, and possibly global climate to evolution of the Himalayan and Transverse mountain systems. The Himalayan mountain system is thought to be fully evaluating this relationship, but is incompletely known. For example, it has been proposed that motion on the Main Central Thrust (MCT), generally thought to be the earliest of the crustal-scale thrusts in the collision zone, is responsible for development of the Northern Himalayan normal fault (NHF). However, the timing of movement on the MCT is poorly understood. We have recently documented two previously unrecognized thrust systems, the north-dipping Gangdese system (GTS) and the younger south-dipping Rehns-Zedong system (RZT), that have implications for the timing and motion of the MCT. West of Lhasa, the GTS juxtaposes the Late Cretaceous-Eocene Gangdese batholith (GB) over Tethyan rocks. Near Zedong, the GT is marked by a 3000-m thick mylonitic shear zone. Based on 40Ar/39Ar thermochronometry, the age of the GT is constrained to between 27 and 24 Ma with a minimum slip rate of 7.3 mm/yr. Displacement of at least 50 km is suggested from the length scale of rocks north of the upthrust during the early Eocene. The early Eocene rapid cooling previously observed in the northern and central GB very likely reflects the onset of rapid denudation following crustal thickening at these locations. Northwest of Xigaze, a major south-dipping backthrust in the hanging wall of the Gangdese thrust on the Xigaze terrane and the GB. A N-dike that cross-cuts the backthrust places a lower bound of 17.8±0.8 Ma on the age of the MCT, and may indicate modes E-W extension associated with this early thickening phase. In places, the younger RZT is thrust over the trace of the GT and unoriented sediments suggests it may locally be active. Because the sequence of thrust development on the southern edge of the collision zone has been younging southward, the age of the GT may provide an upper age limit of 24 Ma for the initiation of movement on the MCT. This is consistent with the timing of initiation of extension along the Xigaze and Kham graben, and dislocation from an overtop of amphibolite 2 m away yield an age of 6.3 ± 0.9 Ma (Tk; 550°C) and minimum age of 4.0 ± 0.2 Ma (Tk; 200°C), respectively. These three data constrain the timing of reactivation of older metamorphism to pre-11 Ma while the 40Ar/39Ar data suggest very rapid cooling in the interval 70 to 4 Ma, which we interpret to be the result of normal faulting. Other thermochronologic and paleomagnetic data from the shear zone and the interior of the range constrain the structural development of the Nyainqentanglha and are consistent with initial formation of the Nyainqentanglha granites in the late Eocene. If, as has been suggested, the formation of the grabens in southern Tibet is the result of the Tibetan Plateau reaching a maximum sustainable elevation, then these data from the Nyainqentanglha indicate a high plateau since ca. 7.5 Ma. This is consistent with data that indicate a change in climate (intensification of the Asian monsoon) at about 6.9 Ma in central Nepal (Harrison et al., 1993), 7.4-7.0 Ma in northern Pakistan (Quade et al., 1989) and ca. 8.0 Ma in the Arabian Sea (Murray and Prell, 1991).
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provenance signatures. This, along with observed on-strike facies changes, may indicate that basin bottom topography (possibly caused by syn-depositional faulting) led to intra-basin sedimentation patterns.

Two possible models are proposed for the origin of the CBF basin:
1) The mapped Anrider thrust fault on the southwestern edge of the CBF trough (B. Shipp, 1993, Geol. Soc. Am. v. 24, p. 147) is coupled with thrust-related mobilization of already deposited limestone turbidites suggests that a significant transgression of the ocean basin may have occurred. This model is consistent with the idea that the CBF is a tectonically active part of the Accretionary Complex.
2) Rates of sedimentation and basin subsidence are similar to those observed in the northern Pennsylvanian Aoka Formation in the Arkansas foreland basin of the Ouachita region of Oklahoma and Texas.

11:45 AM DeCelles, P. G.

THE CANYON RANGE CULMINATION, CENTRAL UTAH SIERRA THREAT BILL: LONG-TERM CONTROL ON SYMMETROSYNCLINE SEGMENTATION IN CORDILLERAN FORELAND BASIN

DeCelles, P.G., Dept. of Geosciences, Univ. of Arizona, Tucson AZ 85721; MIRTA, G., Dept. of Geology, Univ. of Rochester, Rochester NY 14627; and LAWTON, T.F., Dept. of Geology, New Mexico State Univ., Las Cruces NM 88003.

The Canyon Range thrust (CRT) in central Utah juxtaposes a several-km-thick sheet of Precambrian and Cenozoic strata and a formerly continuous Devonian and Cretaceous sequence of carbonate and quartzite, the youngest unit in the system. The CRT extends across both limbs of the system, and is incorporated into a growth fault-propagation anticline.

The Cretaceous carbonate sequence includes a significant component of younger strata. The CRT is overlain by a growth anticline in the western Canyon Range. The structure is reactivated during displacements on thrusts that are younger and structurally lower than the CRT.

The CRT is overlapped by the Canyon Range Formation (CFR), a thick (≈1 km) synorogenic, alluvial-fan and deltaic conglomerate sequence. The CFR comprises 8 map units of alluvium, including carbonate and quartzite. The lowest conglomerate unit is present only in the hinterland of the synorogenic CRT sheet. The three units are present in both limbs of the CRT system, as well as in the peripheral footwall of the CRT (i.e., they are not on the CRT). The top two conglomerate units overlap the CRT, extend across both limbs of the system, and are incorporated into a growth fault-propagation anticline. Progressive unconformities in the CRT indicate deposition during folding of the CRT sheet, and minor, out-of-sequence displacement along the front of the CRT.

All of the conglomerates are sheared eastward from both limbs of the synorogenic CRT sheet and from the core of the Canyon Range anticline. These relations indicate that sedimentation during the Cenozoic through Devonian and Cretaceous sequences were derived from Precambrian through Cambrian quartzites. As a result, the overall extension of the CRT and the present-day uplift of the footwall anticline fan, age dates from the CRT are not available, but the presence of marine facies in one of the lower carbonate conglomerates suggests a Turonian or Coniacian age for the latest faulting of the CRT.

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SESSION 65, 08:00 AM Tuesday, October 26, 1993


HCC 309

08:00 AM Macfarlane, Allison M.

TIMING CONSTRAINTS ON THE TECTONIC EVENTS IN THE CRYSTALLINE CORE OF THE HIMALAYA, LANGTANG NATIONAL PARK, CENTRAL NEPAL

Macfarlane, Allison M., Department of Geography and Earth Systems Science, DePauw University, Greencastle, IN 46135; and VAN HAMEREN, John, Department of Earth Sciences, Syracuse University, Syracuse, NY 13244.

In Oligocene to Miocene times, significant shortening in the hinterland of the Himalayan orogeny occurred within Indian plate rocks. Two major faults that outcrop in the Nepal Himalaya, the Main Central Thrust (MCT) and the Main Boundary Thrust (MBT), account for most of this shortening. Recently [Macfarlane and others, 1993], a geochronologic data on units from the MCT zone and its hanging wall at Langtang National Park indicate a complex history for both of these major faults. Detailed mapping revealed two distinct phases of faulting associated with the MCT, and early syn-metamorphic dextral phase of motion and a late brittle phase of thrust motion. Recent age determinations on the MCT zone reveal increased motion on the MBT. This, the still-active MCT is constrained to have been active in Paleogene times at Langtang. Dextral deformation on the MCT is constrained by age determinations of metamorphic muscovites to have occurred prior to 5.5 Ma. Similarly young [Macfarlane and others, 1993] ages from micas within the hanging wall (4-6.9 Ma) contrast with U-Pb dates of 16-20 Ma from metamorphic monazites and zircon from hanging wall micas. (Parish et al., 1991) suggesting that the majority of the hanging wall experienced relatively slow cooling in Miocene time. An age of 19.3 Ma for a biotite from an uppermost hanging wall mica, suggests rapid cooling, perhaps in response to unroofing along the South Tibetan detachment system, outcropping to the north.

08:15 AM Sorkhabi, Rasoul B.

FISSURE-TRACK THERMOCRONOLOGY IN THE HIMALAYA: PROGRESS, PROBLEMS, AND PROSPECTS

SORKHABI, Rasoul B. and STUMP, Edmund, Department of Geology, Arizona State University, Tempe, AZ 85287.

Fissure-tracking dates appear 30 years ago with Proctor and Walker’s development of a procedure to use chemically etched fissure tracks in uranium-bearing minerals for age determination. With improvements that fissure tracks are sensitive to relatively lower-temperature thermal events and hence their potential in unraveling the recent evolution of orogenic belts, such as the Himalaya, the FT technique underwent something of a renaissance. In the past two decades, several FT studies have been carried out in the Himalaya, especially in the trans-Himalayan and the Higher Himalayan Crystalline rocks in Pakistan and India. After a critical overview of these studies, we will touch on some of the problems associated with the FT thermochronology such as precision and accuracy of the ages with special emphasis on the Himalaya. We will then highlight some of the developments in FT thermochronology such as track-length measurements and how they can be of use in Himalayan studies. Using FT experiences from the Himalaya as well as from other orogenic belts, various strategies for reconstructing and testing the histories of igneous rocks, metamorphic belts, and sedimentary basins will be discussed in order to demonstrate their prospects in tackling geological problems in the Himalaya. Particular attention will be paid to geological interpretation of FT data within the overall framework of thermochronology and in relation to landscape development.

08:30 AM Parrish, Randall R.

MIocene (22:1 Ma) METAMORPHISM AND TWO STAGE THRUSTING IN THE GREATER HIMALAYAN SEQUENCE, annapurna sanctuary, NEPAL

PARRISH, RANDALL R., Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A 0E8, and HODGES, K. V., Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts, 02139

We have used U-Pb dating of zircon and monazite to determine the chronology of structural events in the Greater Himalayan Sequence from the Annapurna Sanctuary, central Nepal. These data indicate that:

- Deformed 22.5 Ma old and contains inherited monazite. Deformed post-kinesine pegmatite which crosses Formation II calc-silicate gneiss has zircon 22.1 Ma old and lacks inheritance. Formation III, previously thought to be granite gneiss of Paleozoic age, has 3541 Ma monazite as well as inherited zircon 620 Ma and younger to appear to be a deformed Oligocene in-situ gneiss. The Aarik Formation, which lies above Formation III, has south-directed dextral kinematic indicators and appears to be structurally conformable with the underlying Greater Himalayan sequence. A normal fault was not recognized at this contact. Highly sheared allaios-bearing pegmatites within calc-silicate schist of Annapurna Formation are also 22.09±0.5 Ma old and indicate that south-directed thrusting is younger than 22 Ma and may have occurred in sequence of respect to the ductile MCT. A brittle normal fault separates the Annapurna Formation from overprint metamorphosed rocks within the Tertiary sedimentary sequence and constitutes the main metamorphic break in this area. It may be a branch of the South Tibetan Detachment.

08:45 AM Coleman, M. E.

WEST-DIRECTED EXTENSIONAL DEFORMATION IN THE NORTHSARSANGI RIVER REGION, WEST-CENTRAL NEPAL HIMALAYA.

COLEMAN, M.E., Department of EAPS, Massachusetts Institute of Technology, Cambridge, MA 02139-4307.

Orogen parallel, syn-compositional normal faults have been identified in several parts of the Himalayan orogen, and it has been suggested that extensional tectonics has been episodic during the convergent evolution of the range. New research in the upper Marsyangdi valley, west-central Nepal, provides direct evidence for three generations of west-directed extensional structures. The lower tectonometamorphic stratigraphy of the study area consists of a 12 km-thick section of high-grade metamorphic rocks of the Greater Himalayan sequence (GH). Throughout the GH compositional layering (Sc) has been transposed by Fr-1 foliated folds into parallelism with the predominant 5f foliation (NE strike, 250°-45° dip to NW). At the top of the GH a northward-dipping dextral shear zone, the Chame detachment (Dj2) places a 4 km-thick section of medium-grade marbles of the Cambrian Annapurna Yellow Formation (AYF) on the GH. The detachment dips 25°-30° NW, subparallel to 5f foliation in the footwall. 5f foliation is well defined within the slope zone. Mineral and structural lineations (Ls) are oriented E-W, shallowly dipping to the west. Dy kinematic indicators in the footwall, including S-C fabrics and west-verging F2 folds, consistently indicate a sense of shear with top to the west, obliquely down dip of the detachment. 5f persists into the hanging wall, where sheared-off, preserved F2 folds are oriented at a consistent angle to S, indicating west-directed shearing. Tourmaline pegmatites, both concordant and discordant to the 5f detachment are abundant in the hanging wall and footwall. A 300 m long, northeast trending 2000 m thick section of AYF is located 3 km up-section from the base of the AYF, and is interpreted to be younger than batholith and in the footwall. The ultramafic pegmatic rocks are transposed into parallelism with S3 mylonitic fabrics within the upper detachment zone. D3 S-C fabrics and asymmetric west-verging folds indicate movement with top to the west (obliquely down dip of the Dj2 detachment). In the upper part
ABSTRACTS WITH PROGRAMS

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*Representatives serve on the 1993 Joint Technical Program Committee