geologic maps, a coincident, apparent, left-slip offset of the southern Tethyan belt and South Tibetan Detachment System (STDS). The new observations, which include the field identification of the intersection of the STDS with the western side of the rift, suggest that the Yadong Cross Structure is the surface manifestation of a lateral ramp in the Main Central Thrust, which has produced a differential, E-W, vertical displacement of the High Himalayan crystalline thrust sheet of about 10 km -- shallower to the E. The exposed, high-angle, Chomolhari normal fault system, which bounds the E side of the southern Yadong-Gulu rift, appears to be a late normal fault superimposed on the N-trending monoclinal flexure of the High Himalayan crystalline thrust sheet produced by the lateral ramp. Recent seismicity suggests that the High Himalayan crystalline thrust sheet is still moving southward along the ramp, and regional geologic relations suggest that the formation of the ramp may be related to a major lateral change in the structure of the underthrust Indian plate.

3:00 PM Murphy, Mike A.

STRATIGRAPHIC AND STRUCTURAL DEVELOPMENT OF THE MESOZOIC (?) GUGU LA THRUST SYSTEM, SOUTH-CENTRAL TIBET

MURPHY, Mike A., YIN, A., HARRISON, T.M., Dept. of Earth and Space Sci., UCLA, Los Angeles, CA 90024; DURR, S.B., Mineralogisches Institut, Am Hubland, 97074 Wurzburg, Germany; CHEN, Z.L, Institute of Geomechanics, Beijing, P.R. China

Geological mapping, conducted at a scale of 1:100,000 in the northern Choqin area, reveals a previously unrecognized Mesozoic (?) thrust system, the Gugu La system. The hangingwall of the thrust consists of five major stratigraphic units of Cretaceous ages, which are based on fossils both collected in the field and documented in Chinese literature. From older to younger, they are (1) andesitic and rhyolitic flows interbedded with sandstone and conglomerate (~250 m thick); (2) limestone interbedded locally with volcanic breccias and sandstone, the latter locally contain clastic dikes (~50 m thick); (3) green and red tuff and dark green and gray pyroclastic breccia (>500 m thick); (4) red fluvial sandstone with a south-derived source (>500 m thick); and (5) gray sandstone and conglomerate which is rich in volcanic clasts (>200 m) and is interpreted to be derived from the north. In the footwall, a 2.5 km thick red conglomerate interbedded with sandstone is present, which is generally N-dipping. However, it is folded near the Gugu La thrust. The clasts of the conglomerate and sandstone can be correlated with the rocks from the hanging wall of the Gugu La thrust. The Gugu La thrust is S-directed, dipping 10-20ºN. Striations measured directly from the Gugu La fault zone indicate its mean transport direction as S10ºE. The thrust juxtaposes different hangingwall units along strike for a distance of 100 km as we mapped. In the eastern mapped area, it puts unit (4) over the footwall conglomerate. In the western area, the thrust juxtaposes unit (3) in the hangingwall. In its central part, the thrust has the largest stratigraphic throw and puts unit (1) over the footwall conglomerate. The hangingwall structures are typically fault-bend/-propagation folds, and pop-up structures at lower stratigraphic levels, and broad folds at higher stratigraphic levels. Change in deformation styles at different stratigraphic levels is due to formation of bedding-parallel decollements as well as syn-folding sedimentation such as unit (5) in the hangingwall. Balanced cross sections across the area suggest a minimum displacement of 8.5 km along the Guga La thrust. The folded Cretaceous strata in the hangingwall are intruded by both N-S trending dikes and granodiorite. The contractile structures and the intrusives are, in turn, unconformably overlain by a sequence of flat-lying tuff. Because the tuff has a similar lithology to the early Tertiary Linzizhong volcanics in the Lhasa region, as well their similar stratigraphic and structural relations, we interpret that the N-S contractional deformation in the Gugu La thrust system occurred prior to the Indo-Asian collision. All of the structures and lithologic units in the Gugu La thrust system are cut by N-S trending normal faults with offsets between tens and hundreds of meters. Their development was related to the formation of the N-S trending Dawa Co rift in the northeastern mapped area.

3:15 PM Ryerson, F. J.

THE GANGDESE AND RENBU-ZEDONG THRUST SYSTEMS: WESTWARD EXTENSION TO MT. KAILAS

RYERSON, F.J., IGPP, Lawrence Livermore National Laboratory, Livermore, CA 94550, YIN, A., HARRISON, T.M. and MURPHY, M.A., Dept. of Earth and Space Sci. and IGPP, UCLA, Los Angeles, CA 90024

The feature referred to as Indus-Tsangpo suture is marked by the N-dipping Gangdese (GT) and S-dipping Renbu-Zedong thrust (RZT) systems. Existence of the GT was first hypothesized based on rapid early Miocene cooling in the southeastern Lhasa block and the absence of Xigaze forearc sediments east of Renbu. The trace of the GT is commonly obscured by the younger RZT system, which thrusts Tethyan metasediments over Tertiary conglomerates, a collisional melange, and the Gangdese batholith. From Renbu to ~83ºE, the GT thrusts Xigaze forearc sediments over Tethyan metasediments. West of ~83ºE near Mt. Kailas, the characteristics that initially identified the GT are once again in evidence. The Xigaze forearc sediments are absent, and thermochronologic analysis of a Gangdese granite cobble from the Kailas Conglomerate, which lies unconformably atop the Gangdese batholith, suggests rapid early Miocene cooling. Our mapping in the Mt. Kailas region confirms the existence of the RZT, which comprises a number of south-dipping thrust imbricates in a 7-10-km wide zone. Thrusts in its southern part juxtapose a ophiolitic complex over Cretaceous limestone, shale, and sandstone, and are tightly folded with a northward vergence. The thrusts in its northern part are planar and put the Cretaceous sedimentary rocks over the Kailas Conglomerate, suggesting a foreword development in the Mt. Kailas region. The Kailas Conglomerate is a >1.5-km thick sequence of clastic sediments. Its lower part (200-400 m) consists mainly of granite and volcanic clasts derived from the Gangdese batholith. Its middle part (~1-km thick) consists of coarse-grained sandstone with clasts derived from both the Gangdese batholith and the Tethyan sequence. Specifically, cobbles of the Gangdese plutonics dominate the basal section, replaced by cobbles of metasediments, cherts, and ophiolite higher in the section. The structurally uppermost part of the Kailas sequence (>200 m thick) is in a thrust contact over the middle part. It consists of large boulders and cobbles derived from the adjacent Tethyan and Cretaceous sequences from south. The above observations suggest that the Kailas basin was initially fed by sediments derived from the Gangdese batholith. Subsequent deposition of Tethyan cobbles was derived by loading of the basin and denudation of Tethyan rocks during development of the RZT. Although the GT is not exposed, the rapid denudation of the Gangdese batholith at Mt. Kailas in the early Miocene and the absence of Tertiary normal or thrust faults north of Mt. Kailas suggest that the Gangdese batholith was denudated by thrusting-related erosion. We attribute this event to the development of the GT, now buried below the RZT. This study suggests that the GT and RZT systems were continuous between Bayi in the east and Kailas in the west over a distance of 1,200 km.

3:30 PM Yin, An

SIGNIFICANT CRUSTAL SHORTENING IN THE LHASA BLOCK (SOUTHERN TIBET) PREDATES THE INDO-ASIAN COLLISION

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Geological mapping at a scale of 1:100,000 was conducted in the Choqin region, south-central Tibet. A 150-km long N-S transect reveals three E-W trending thrust systems (Gaize, Gugu La, and Shibalou). The northernmost Gaize thrust is S-directed and puts the Jurassic sedimentary and volcanic rocks over the lower Cretaceous limestone and early Tertiary(?) conglomerate. Deformation along this thrust disrupted the original suture between the Lhasa and Qiangtang blocks. The Gugu La thrust, south of the Gaize thrust, is S-directed. It juxtaposes a >2.5-km sequence of Cretaceous(?) volcanics, limestone, and fluvial sediments in its hangingwall over a >2.5-km thick sequence of conglomerates in its footwall. The folded hangingwall sequence is intruded by a granodiorite with a minimum age of 95 Ma. In the footwall of the Gugu La thrust is the Shibalou thrust system, the most intensely deformed system. Its northern part consists of both N- and S-directed thrusts which were crosscut by a granodiorite intruded at 115±5 Ma. The southern part consists exclusively of S-directed thrust imbricates, duplexes, and S-verging isoclinal folds which are crosscut by a granitoid with a minimum age of 135 Ma. This thrust system involves Cretaceous (?) volcanics and Paleozoic shallow-marine sediments. The deformed strata were unconformably overlain by a >200-m thick volcanic tuff locally interbedded with conglomerate and sandstone. The tuff is cut by minor N-S trending normal faults. The folded Paleozoic strata are crosscut by several granitoids. Because the folded fluvial sequence in the Gugu La hangingwall was derived from south, we interpret its deposition as the result of the development of the Shibalou thrust system south of the Gugu La thrust. This implies that the Gugu La thrust postdates the Shibalou thrust. Because of the similar lithology and structural positions, we correlate the flat-lying Choqin tuff in the mapped area with the Paleocene Linzizhong Fm. Reconnaissance investigations north of Mt. Kailas indicates a similar relationship, i.e., Cretaceous strata are highly folded whereas the early Tertiary volcanics are flat-lying. In eastern Tibet, the same relationship has been long known in the Machu area. It has long been noted that relatively little deformation observed on the Tibetan Plateau can be confidently be ascribed as Tertiary. We can now rule out significant Tertiary deformation in a N-S transect across the Lhasa block from the Gangdese thrust to the Banggong suture. Mesozoic N-S shortening in southern Tibet and the absence of upper-crustal shortening during the Indo-Asian collision suggest that the uplift history of the Tibetan plateau had begun by the Mesozoic. Tertiary thickening and uplift could have been accomplished by underthrusting, delamination, or injection of Indian crust, but appears unlikely to have occurred by uniform shortening of the entire Asian lithosphere.

3:45 PM Nelson, K. D.

INDEPTH II (1994) DEEP CRUSTAL PROFILING IN SOUTHERN TIBET

NELSON, K.D., WU, C., COGAN, M., Dept. of Earth Sci., Syracuse Univ., Syracuse, NY, 13244; BROWN, L., HAUCK, M., ALSDORF, C., CLARK, M., Dept. of Geol. Sci., Cornell Univ., Ithaca, NY 14853; KLEMPERER, S., MAKOVSKY, Y., Dept. of Geophys., Stanford Univ., Stanford, CA; NI, J., SANDVOL, E., Dept. of Phys., New Mexico State Univ., Las Cruses, NM 88003, NABALEK, J., Col. of Ocean., Oregon State Univ., Corvalis, OR 88003; KIDD, W., EDWARDS, M., Dept. of Geol. Sci., SUNY at Albany, Albany, NY 12222; ZHAO, W., LI, J., YUE, Y., Chinese Aca. Geol. Sci., Beijing, China

In 1994 Project INDEPTH (International Deep Profiling of Tibet and the Himalaya) collected 200 km of new CMP reflection , wide-angle reflection/refraction , teleseismic and surface geological data in southern Tibet. These data, together with the ~100 kms acquired during INDEPTH I, constitute a discontinuous deep seismic traverse extending along the Yadong-Gulu rift from the crest of the Himalaya to the north end of the Damxung graben. Some key results are as follows: 1) The decollement along which India is underthrusting southern Tibet is traceable as a distinct, gently N-dipping, reflection band to a point approximately 220 km north of the Himalayan thrust front and to a depth of approximately 45 km (approximately the center of the Tethyan belt). 2) The Kangmar Dome appears to be a duplex ramp anticline formed above a crustal ramp in the basal decollement. 3) The South Tibetan and Kangmar detachments appear to be the same structure. 4) A throughgoing gently N-dipping structure in the upper crust extends beneath the Tsangpo suture, apparently cutting off, or forming a floor to, the subvertical structure of the suture zone observed at the surface. 4) Discontinuous, anomalously high-amplitude, reflections are observed beneath the Yangbajain/Damxung grabens. These high-amplitude reflections are qualitatively similar in depth and character to anomalously high-amplitude mid-crustal reflections that have been associated with magma bodies beneath other active rifts (e.g. Rio Grande Rift). 5) Moho is clearly observed on INDEPTH CMP profiles only beneath the southern Tethyan belt (Dogen valley), where it occurs at ~75 km depth (23-24 s). 6) Receiver function Moho depth determinations along the Yadong-Gulu rift, however, are consistently in the 75-80 km range, implying a regionally flat Moho between the crest of the Himalaya and the north end of the Damxung graben. 7) Preliminary of analysis of P-to-S (teleseismic) converted phases suggests a "shingled" structure in the lower crust beneath the region, and a major, moderately-steeply north-dipping, structure (fault?) within the upper mantle. The latter appears to intersect (project to) the base of the crust beneath southern Tethyan Himalaya, well south of the Tsangpo suture.

WED pm

4:30 PM Lehmann, Christoph

DEPOSITIONAL FACIES, SEQUENCE STRATIGRAPHY AND DROWNING OF THE COAHUILA CARBONATE RAMP (ALBIAN), NORTHEASTERN MEXICO

LEHMANN, Christoph; OSLEGER, David A.; MONTAÑEZ, Isabel P.,
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The Lower Cretaceous (Albian) Coahuila carbonate platform of northeastern Mexico is coeval with the economically-significant Valles and Golden Lane (Tuxpan) platforms to the south and the Glen Rose-Edwards-Stuart City platform to the north in Texas. Approximately 16,000 m of the Acatita/Aurora/Upper Tamaulipas Formations have been logged on a decimeter-scale over an area of 100,000 km^2 to determine platform geometry and facies relationships, and to develop a sequence stratigraphic framework for the Coahuila carbonate platform.

The Coahuila carbonate platform is a distally steepened ramp attached to the Coahuila basement block. Three distinct facies assemblages characterize the three major paleogeographic elements of the Coahuila ramp. 1) The ramp interior (Acatita Formation) is composed of more than 60 evaporitic parasequences deposited in a hypersaline lagoonal environment. The evaporitic parasequences are composed of a basal evaporitic lithofacies shallowing upward to a high-energy, skeletal, peloidal packstone/grainstone. 2) The ramp margin (Aurora Formation) is composed of a massive ooid-peloid grainstone that exhibits progradational geometries, representing a high-energy barrier shoal. Up to 140 peritidal parasequences overlie the massive grainstone, reflecting protected tidal-zone environments in the lee of the barrier shoal. Meter-scale parasequences are composed of a basal, skeletal, peloidal grainstone containing rudists, fining and shallowing-upward into a dolomitized fenestral mudstone or tidal-flat laminite. 3) The deep ramp (Upper Tamaulipas Formation) is composed of muddy hemipelagic lithofacies and can be subdivided into a proximal hemipelagic subfacies and a distal hemipelagic subfacies separated by a locally-developed steepened slope.

Both the evaporitic and peritidal parasequences are interpreted to represent high-frequency accommodation events (10^4-10^5 year range). These parasequences are arranged in several parasequence sets and form a pattern of long-term decrease in accommodation space, culminating in a major sequence boundary (mid-Albian), followed by an increase in accommodation space. The Coahuila carbonate platform was abruptly drowned, marked by the deposition of a 20 m thick, planktonic foram-dominated, silty, laminated mudstone. This drowning event terminated Cretaceous platform development in the region and might coincide with the late Albian globally recognizable Oceanic Anoxic Event (OAE 1C).

4:45 PM Prothero, D. R.

MAGNETIC STRATIGRAPHY OF THE LATE MIDDLE EOCENE COLDWATER FORMATION, CENTRAL VENTURA COUNTY, CALIFORNIA: IMPLICATIONS FOR SEQUENCE STRATIGRAPHY

PROTHERO, D.R., and VANCE, E.H., Jr., Department of Geology, Occidental College, Los Angeles, CA 90041

Until recently, the middle Eocene Coldwater Sandstone could not be precisely dated beyond its "Tejon Stage" molluscs (which range from 33-44 Ma). Yet the upper Coldwater redbeds (which grade into the the overlying middle Eocene Sespe Formation in upper Sespe Creek, Ventura County, California) produces several mammalian faunas which greatly improve the biostratigraphic control. After removal of magnetic overprinting by stepwise thermal demagnetization, most samples yielded a stable primary remanence that passed a reversal and fold test, and shows a clockwise rotation of about 100° ± 17° (consistent with other pre-Miocene units in the western Transverse Ranges). Magnetic stratigraphy and refined chronostratigraphy of the late Uintan and Duchesnean mammals found within the redbeds in the Coldwater show that the upper Cozy Dell-Coldwater-Sespe sequence in central Ventura County spans Chrons C19r-C18n (approximately 39.5-42.5 Ma). The late Uintan Hartman Ranch l.f. occurs near the top of Chron C19n (about 41.2 Ma), in good agreement with the magnetostratigraphic position of the similar Tapo Canyon and Brea Canyon local faunas in Simi Valley. Several Duchesnean localities (with *Duchesneodus* and *Amynodontopsis*) are known in this area; these all occur in early Chron C18n (about 40 Ma).

These new biostratigraphic and magnetostratigraphic data allow a test of two recent sequence-stratigraphic models proposed for the Cozy Dell-Coldwater-Sespe Formations. Campion et al. (1994) interpreted three sequence boundaries in this interval, which they correlated with the Ta3.6-Ta4.4 parts of the Haq et al. (1987) curve. With better chronostratigraphy, it is clear that none of these three sequence boundaries are eustatically controlled, and they are miscorrelated by 4-5 million years (they actually occur within Ta3.4 or Ta3.5). Clark (1994) recognized three different sequence boundaries in the same sections, but did not suggest eustatic control; indeed, none of his sequence boundaries match the Haq et al. (1987) curve, either. Such mismatches further reinforce the caveat that sequence-stratigraphic correlations are only as good as the biostratigraphic data on which they are based.

5:00 PM Pinous, O. V.

Upper Eocene - Lower Miocene Facies, Sequences, and Sea-Level Change Interpretation from the Strata of the Northern Aral Sea Region (Kazakhstan).

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The Northern Aral region was in the northeastern part of Upper Eocene - Early Miocene Tethys, and was a transitional zone between continental and marine depositional environments on a passive margin. Clastic and carbonate deposition occurred in a range of facies from fluvial and lacustrine in coastal plains (Turgai Trough) to deep marine with condensed sections and turbidites (Usturt Plateau). The section is characterized by explicit cyclicity which is interpreted to be caused by tectonic subsidence, sediment supply rate, and eustasy. Parallic facies (deltaic, lagoonal, estuarine), that comprise the transition zone from continental to marine sedimentation are especially sensitive to the relative sea-level change. The excellent exposure of these strata in numerous outcrops and the presence of a number of wells drilled throughout the area makes it possible to examine in detail different facies successions and trace their lateral and vertical transitions within the stratigraphic units. Preliminary stratigraphic and sedimentologic analyses of outcrops and wells made it possible to subdivide the section into depositional sequences and reconstruct the development of the depositional systems and their response to sea level change. Despite significant spatial in tectonic subsidence and sediment supply rates, sequences and systems tracts can easily be traced throughout the margin. Preliminary results suggest that the margin developed in a tectonic and sedimentary regime generally similar to the U.S. Atlantic and Gulf margins, and that eustasy played a major role in controlling sedimentation. However, in some biostratigraphically poorly correlated intervals, sea-level events reflected in the Aral sections do not correspond to those reported from Atlantic and Gulf Coast margins. For example, the most significant sea level fall in the Aral region appears at the Eocene/Oligocene boundary or in Lowermost Oligocene (according to present biostratigraphic data), but in the U.S., a similar sea level fall is inferred in the Middle Oligocene. While it is possible that the interplay between subsidence and sedimentation conspired to cause the basal Oligocene event in the Aral region and the Middle Oligocene event in the Atlantic and Gulf margins independently, we consider it more likely that they were caused by the same eustatic event, and that the biostratigraphic correlation of the Aral strata bear re-examination. Subsequent detailed stratigraphic analysis of the Aral sections may provide important data for identification of true Eocene-Miocene eustatic events.

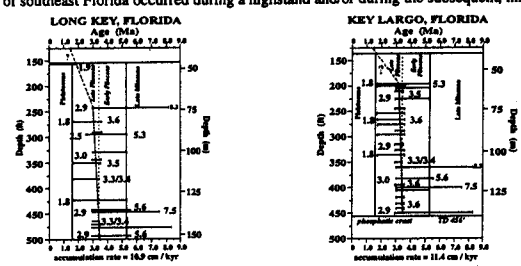
5:15 PM Guertin, Laura A.

HIGHSTAND(?) MOBILIZATION AND EMPLACEMENT OF NEOGENE SILICICLASTIC SEDIMENTS, SOUTHEAST FLORIDA

GUERTIN, Laura A., MCNEILL, Donald F., Univ. of Miami, RSMAS-MGG, 4600 Rickenbacker Cswy., Miami, FL 33149; LIDZ, Barbara H., USGS Center for Coastal Geology, 600 4th St. South, St. Petersburg, FL 33701.

Two new continuous core borings show a surprisingly thick (~100 m) package of siliciclastic sediments in the shallow subsurface of the Florida Keys. The siliciclastic sediments are underlain by middle Miocene(?) limestone and overlain by latest Pliocene(?) and Pleistocene limestone, serving as the foundation for the modern Florida reef tract. Initial results from biostratigraphic (planktic foraminiferal) data indicate that marine deposition of these siliciclastic sediments on the southeast Florida peninsula occurred during the middle Pliocene (~3.6-2.9 Ma).

Age/depth plots have been generated from constraining biohorizons of first and last appearances of key species found in the siliciclastic section of both cores (see figures). The plots suggest that emplacement of the siliciclastics in southeast Florida was at a relatively high sedimentation rate (10.9-11.4 cm/kyr), within a ~0.5 m.y. interval. The middle Pliocene age for the siliciclastics is also coincident with a proposed highstand in sea level (mid-Pliocene warm period) and the initial lowering of sea level associated with the onset of Northern Hemisphere glaciation (~3.2 Ma). If confirmed, these results suggest that the mobilization and redistribution of both the fine- and coarse-grained siliciclastic sediments of southeast Florida occurred during a highstand and/or during the subsequent, initial fall in sea level.



SESSION 120, 1:30 PM
Wednesday, November 08, 1995
Tectonics IV: Himalayan Tectonics
ENM 39

WED pm

1:30 PM Pivnik, David A.

TECTONICS AND SEDIMENTATION IN THE PAKISTAN FORELAND DURING THE PLIO-PLEISTOCENE

PIVNIK, David A., Amoco Production Company, P.O. Box 800, Denver, CO 80201-0800.

Pliocene and Pleistocene syntectonic sedimentation in Pakistan occurred in response to tectonically and geographically varied deformational events related to the most recent stages of Himalayan convergence. The availability of accurate magnetostratigraphic, fission-track, and biostratigraphic ages of the upper Siwalik Group allows for the correlation of synchronous yet structurally disparate deformation that occurred throughout the Himalayan orogen. Superimposed on the backdrop of deposition of the main foreland fluvial system, the Indus River, were numerous basins which received sediment in response to coeval, local tectonism which partitioned the foreland. In the hinterland region, intermontane basins such as the Skardu Basin rapidly aggraded from ~3.0 to 0.75 Ma in response to sediment ponding behind the uplifting Nanga Parbat Massif. The Karewa sequence in the Kashmir intermontane basin records uplift of the Pir Panjal Range from ~4.0 to 1.5 Ma. In the Campbellpore and Peshawar intermontane basins, deposition

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