rise of the leucogranite and (2) that the south-dipping mylonitic schist has been rotated to this orientation, from north-dipping, by the rise of the leucogranite. The detachment fault is interpreted to be the final, brittle evolutionary stage of extension on the STDS. The rise of the Khula Kangri pluton here is thus interpreted to be late in the history of STDS movement, but before the extension on the STDS in this area ceased.

5:15 PM Kidd, W.

THE END (EAST NIERU DETACHMENT). A NEW LOW-ANGLE MYLONITIC SHEAR ZONE BORDERING THE YADONG-GULU RIFT SYSTEM, SOUTHERN TIBET

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The Nieru valley is part of the N-S Yadong-Gulu rift system in southern Tibet, a set of interconnecting Quaternary graben structures developed in response to late Miocene-present W-E extension of the southern Tibetan Plateau. The Nieru Valley is a ~50km long <10km wide half-graben, bounded by Quaternary steep normal faults, of relatively minor offset on the west side, and of more substantial (~3km) throw on the eastern side. The END is a zone of pervasive mylonitisation with a structural thickness of ~500m minimum; these mylonites are capped by a thin (meters) brittle quartz vein breccia detachment fault (sensu stricto), which carries a cover of 500m or more of dark phyllites, of probable Carboniferous stratigraphic age. The END is exposed in a narrow side valley east of the main Nieru Valley, and along this traverse the upper 150m of the END consists of dolomite mylonites; the lower part consists mostly of pelitic/quartzofeldspathic rocks in amphibolite facies. Both mechanical striations and mineral lineation trend W-E, and dip 5-20^0 west (in plane with foliation) along the western part of the traverse, accompanied by top-to-west sense of shear indicators. Because the regional dome that exposes the END is centered on this side valley, the mylonitic horizon dips below the surface both to north, east, and south.

In spite of the close proximity (~20km west) to the Kangmar granite, thought to be a core complex exposed by N-S extension, the END shows evidence only of W-E extension. Allowing for an evolving detachment which repeatedly cuts down into the footwall, the Quaternary (steep) normal faults throughout the Nieru Valley may be interpreted to join the END, forming a basal detachment structure which has allowed the initial E-W extension of the valley, with the observed (steep) normal faults restricted to the detachment hanging wall. The discovery of a W-E extensional detachment here is perhaps unsurprising in view of similar stuctures documented from the Nyainqentanglha Shan, to the north, and reported from Chomolhari, to the south, and it may be that the END is of similar magnitude to these and underlies all of the Nieru valley. This interpretation permits possible earlier N-S movement on it related to the Kangmar detachment and Southern Tibet Detachment System.

Conclusion: Presently available paleomagnetic data and ongoing plate tectonic research provide the regional framework for future comprehensive regional tectonostratgraphic studies related to hydrocarbon habitats. The additional modelling of plate motion trajectories and the implied paleostress fields can then be applied on a higher resolution scale and used for basin-scale structural analysis.

1:45 PM Cronin, Vincent S.

N-PLATE RULE OF PLATE KINEMATICS: HOW COMMON IS CIRCULAR FINITE MOTION BETWEEN ADJACENT PLATES?

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The finite motion of plates relative to one another across a given plate boundary is commonly assumed to be circular, from a basic postulate of first-generation plate kinematics. This assumption is not valid for most boundaries in the current plate system.

The three-plate rule (*after* Cox, 1973) states that there must be non-circular finite motion across the boundary between at least one pair of plates in any three-plate circuit (plates 1, 2 and 3) if angular velocity vectors $_1\omega_2$, $_2\omega_3$, and $_3\omega_1$ are non-zero and non-colinear. A more general form, called the *n*-plate rule, states that in any *n*-plate circuit ($n \geq 3$) that does not close after modeled finite displacement, there must be at least one boundary across which there is non-circular finite motion.

In the current plate system, as described by NUVEL-1 and NUVEL-1A (DeMets *et al.*, 1990, 1994), none of the *n*-plate circuits that were evaluated display closure after modeled finite displacement. Using the *n*-plate rule as a criterion to evaluate a simplified version of the current plate system with 14 plates and 34 plate pairs sharing common boundaries, circular finite motion is possible across no more than 38% of the plate boundaries. Increasing the number of plates and plate boundaries in a model system tends to decrease, rather than increase, the percentage of kinematically admissible circular-motion boundaries. In contrast, non-circular finite motion is kinematically admissible across all current plate boundaries.

This analysis demonstrates that finite motion across most, if not all, current plate boundaries is non-circular.

SESSION 121, 1:30 PM

Wednesday, November 08, 1995

T1. 1995 GSA Annual Meeting Committee: Plate Tectonics, the Next Generation

ENM 24

1:30 PM Lehner, Benedikt

PALEOSTRESS ANALYSIS AS "SPIN-OFF" OF HIGHER RESOLUTION REGIONAL PLATE TECTONIC STUDIES.

LEHNER, Benedikt and DOUST, Harry, SHELL Inter. Petrol. Maatschappij B.V., Postbus 162, 2501 AN The Hague, The Netherlands.

Present global paleomagnetic datasets within academia have become large enough to allow plate tectonic reconstructions of specific regions of interest throughout the Phanerozoic. Currently a number of detailed regional plate tectonic models are being constructed by industry-sponsored study groups at universities as a basis for paleogeographic data compilation in areas of potential interest for future hydrocarbon exploration. These models result in customisation of the available global paleomagnetic data and enhancements in the spatial and temporal resolution of regionally specific plate tectonic data. The introduction of tectonic data into the plate tectonic model provides the framework for regionally focused paleostress analysis based on the modelling of plate motion trajectories for given geologic periods.

It is assumed that maximum or minimum horizontal stresses are partially induced by the mode of lithospheric plate motion, as recent GPS studies and general trends in the World stress database (M.L. Zoback, 1992) highlight the close correspondence between present plate motion vectors and observable regional tectonic stress regimes. This substantiates the applicability of plate motion trajectories as indicators of paleostress on a regional scale, in combination with other tectonic data. Circumstantial structural data (e.g. wellbore breakouts, volcanic alignments, hydraulic fracturing, earthquake focal mechanisms, seismic structure maps and outcrop measurements) can be used to test and constrain the regionally modelled paleostress orientation.

Tectonostratigraphic analysis of hydrocarbon habitats in frontier basins can be integrated with paleostress analysis to validate phases of tectonic subsidence and inversion and help to classify basins according to their tectonic regime. In such a way plate motion data derived from ongoing plate tectonic research can be used in basin-scale tectonostratigraphic analysis and time controlled secondary hydrocarbon migration modelling.

2:00 PM Silver, P. G.

CORDILLERA FORMATION, THE WILSON CYCLE, AND MANTLE FLOW

SILVER, P. G., DTM, Carnegie Institution of Washington, 5241 Broad Branch Rd., NW, Washington, DC 20015; and RUSSO, R. M., Laboratoire de Tectonophysique, Université de Montpellier II, Place E. Bataillon, 34095 Montpellier cedex 5, France.

The Wilson Cycle includes no satisfactory explanation of the formation of continental cordilleras when an oceanic plate subducts beneath an overriding continental plate. Plate tectonic theory, explicitly adopting the rigidity of plates, comes no closer to a solution to this problem. By examining the mantle flow field around South America, we relate Andean orogenesis to the mantle flow beneath the continent's western margin and to its rapid trenchward motion. The Andes formed in response to a 'collision' between westward moving South America and the Nazca subslab mantle, analogous to classic Wilson Cycle continental collision. Resistive horizontal normal stresses that deform the continent also perturb mantle flow beneath the Nazca plate, inducing trench-parallel flow as the subslab mantle is displaced by the advancing continent. Trench-parallel mantle flow, first detected via shear wave splitting observations, proceeds from a central stagnation-point at the continent's leading edge to corner flow around its northern (Caribbean) and southern (Scotia Sea) ends. Thus, we account for the existence of the cordillera, for the large-scale variations in Andean structure, and for the symmetry of the continent and its satellite plates: the continent buckled at the stagnation point (where normal stress is at a maximum) forming the Bolivian Orocline and Altiplano; the eastward motions of the Caribbean and Scotia plates north and south of the Andes are driven by the mantle corner flow. Trenchward motion of South America must be driven by deep mantle flow, given the high stresses required to form and maintain the Andes, and given the lack of any other appropriate driving force. Both South and North America experienced rapid trenchward motion during subduction along their leading edges. Thus, we infer that western North America's Laramide deformation was also a product of trench-parallel mantle flow, resulting in cordillera formation, oroclinal bending, and plateau development. North America's westward motion is also probably driven by deep mantle flow, indicating the presence of a generalized large-scale mantle flow beneath the Atlantic. By contrast, Pacific spreading appears to be the result of subduction-related forces. We propose that active Atlantic spreading is closely linked to cordillera formation in the Americas since such spreading must increase the trenchward velocity of the overriding continental plates, thereby increasing normal stresses transmitted between mantle flow and the leading edge of the continent. The American cordillera is thus a natural consequence of mantle flow forces during the breakup phase of the Wilson Cycle.

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.,
Dept. of Earth Sciences, University of California, Riverside, CA 92521

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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[3]Institute of Geology, Russian Academy of Sciences, Moscow

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.

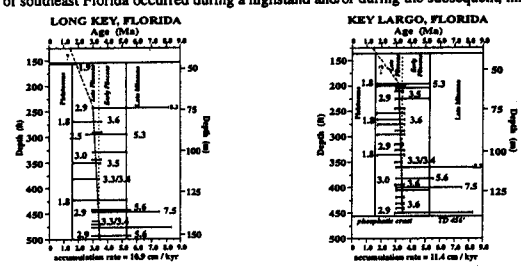
5:15 PM Guertin, Laura A.

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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ABSTRACTS WITH PROGRAMS

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