plutonism. The Ordovician tectonic uplift in the orogenic belt caused the partial erosion of the basement and cover rocks and deposited the synorogenic foreland clastic units of the Misiri Banda, Ghanikot, Galdanian, Yadghar, and Devighar Formations. In the Silurian and Devonian, the shallow water marine deposition occurred on the Indian plate. The Early Mississippian to early Middle Pennsylvanian Jafar Kandao and Chushal Formations mark the Panjal pre-rift phase. In the Late Pennsylvanian Panjal initial rift phase is accompanied by the intrusion of 315±15-297±4 Ma alkaline granites and syenites, > 272 Ma (potash-feldspar Ar/Ar date) sodic granites, and 333-281 Ma (Hb and biotite Ar/Ar dates) metamorphism. In the Early Permian, Panjal syn-rift phase is represented by the deposition of Marghazar, Ajmar, Karapa, Panjal, lower Burawai, lower Gumot Formations and associated major mafic Panjal volcanism (262-284 Ma Hb and Bt Ar/Ar dates). The Early Permian to Late Triassic Panjal syn- to post-rift phase is accompanied by the deposition of the Kashala, upper Burawai, and upper Gumot Formations and local mafic Panjal volcanism.

2:45 PM Ramezani, Jahandar

EARLY CAMBRIAN TECTONOTHERMAL EVENT AND BASIN EVOLUTION IN CENTRAL IRAN: CORRELATION WITH CENTRAL AND WESTERN HIMALAYA.

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New U-Pb geochronologic data from east-central Iran points towards a major episode of Early Cambrian magmatic (and metamorphic) activity which has been traditionally attributed to the late Precambrian (Assyntian or Pan-African) orogeny. The emplacement of granitoid plutons and explosive volcanism associated with this event were largely coeval with the widespread development of shallow carbonate-evaporite basins along the northern perimeter of the early Paleozoic Gondwanaland.

The Central Iranian Microcontinent (CIM) is a fault-bounded, composite terrane within the Alpine-Himalayan (Tethyan) orogenic system. It is a collage of several crustal fragments with a complex, Mesozoic and Cenozoic history of suturing and deformation. The early Paleozoic (and older) rocks of the CIM are exposed exclusively along a 400-km arcuate belt in the fault-dominated western sector of the microcontinent. In the Saghand area of this belt, the oldest, virtually unmetamorphosed strata consist of a ca. 2000 m thick, uniform sequence of graywackes and mafic volcanic-volcaniclastic rocks known as the Tashk Formation. Detrital, single zircon grains from a Tashk volcaniclastic yield a range of ages from ca. 1900 Ma to 625 Ma. This brackets the timing of sedimentation between 625 Ma and 535 Ma, the crystallization age of the oldest granitoid intrusion into the Tashk formation. The 535-529 Ma interval marks an abrupt transition from the Tashk clastic sedimentation to a succession of bedded, locally gypsiferous, dolomites and felsic tuffs, formerly referred to as "Infracambrian". A rhyolitic tuff near the base of this unit yielded a U-Pb zircon age of 530 ±2 Ma. The latter (and the Tashk Formation) was intruded by a series of late-stage leucogranite intrusions dated at ca. 527 Ma.

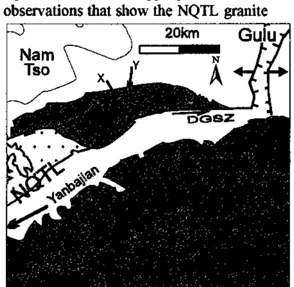
The Tashk Formation bears close similarities to many late Proterozoic-early Cambrian successions reported from the Lesser Himalaya (e.g. Kumaun and Himachal sections) and Peninsular India. The distinct evaporite-carbonate sequence of the Saghand area appears to be part of a widespread early Cambrian facies that extends throughout central Iran (Rizu Series), The Zagros Basin and the Persian Gulf (Hormuz Formation) and the southeastern Arabian Peninsula (Ara Formation), and can be traced as far east as the Salt Range of northern Pakistan and the western Himalaya. Analogous to that in Central Iran, a great tectonomagmatic event of (late Proterozoic-) Cambrian age brought the early Cambrian sedimentation to an abrupt end in the lesser Himalaya and resulted in a major unconformity between the lower Cambrian and the upper Paleozoic (or younger) strata. The reported extensive 500-600 Ma old granite intrusions in the crystalline nappes of Lesser (and Greater) Himalaya were probably related to the same tectonothermal event that resulted in the 535-527 Ma magmatism in central Iran.

3:00 PM Edwards, M. A.

STRAIN PARTITIONING AT NORTHEAST NYAINQENTANGHLA, SOUTHERN TIBET

EDWARDS, M.A., **KIDD**, W.S.F., Department of Geological Sciences, State University of New York at Albany, 1400 Washington Avenue, Albany, NY 12222 (me7685@csc.albany.edu); **JIXIANG LI**, Chinese Academy of Geological Sciences, Beijing 100037, China.

The Nyainqentanghla Shan (NQTL) is a core complex (cc) on the western margin of the Yadong-Gulu Rift System (YGR) in southern Tibet. The NQTL cc mylonite (NSZ) shows ~top-to-east normal shear related to opening of the YGRS since ~8Ma. Edwards et al. (1995) described two other footwall mylonites from elsewhere (Nieru & eastern Pali) along the YGR, indicating that the large E-W extensional strain ubiquitous to the NQTL is characteristic of the YGR, and consequently the extensional strain represented by Tibet's "Quaternary" graben systems may have been under-estimated by an order of magnitude. NE of the NQTL, the continuation of the NSZ is not clear. The NQTL granitic core northern margin seems to be intrusive, requiring that the NSZ here is either (1) obliterated by later plutonism, (2) no longer the granite/cover contact, or (3) sufficiently above erosion level to show no footwall effects. Although #1 & #2 are supported by observations (see X & Y, fig. 1) of an overturned synform with a SE-dipping axial plane below a SE-dipping normal fault (predicted by Cogan's (1995) NQTL cc model), and by new observations that show the NQTL granite is intrusive on the NW side, a newly-discovered, large (300m x 30km), W-E ~vertical, sinistral (i.e.#3) mylonite zone, the Damxung-Gulu Shear Zone (DGSZ) suggests the NSZ steepens and continues to Gulu. A An early ~horizontal lineation is overprinted by a ~down dip stretching lineation (70°@100° ±10°) probably due to (Quaternary?) initiation of the Damxung pull-apart structure. An *un*stretched conglomerate found just north of the mylonite has a stretched counterpart to the west (see Z, fig. 1) interpreted (Armijo et al. 1989) as a dextral shear, possibly a former part of the Karakorum-Jiali system. However, the DGSZ requires sinistral shear after 8Ma, and data from Searle (1996) suggests the Karakorum-Jiali system cannot be pre-Pliocene.



3:15 PM Burchfiel, B. C.

TECTONIC EVOLUTION OF THE EASTERN TIBETAN PLATEAU

BURCHFIEL, B C., ROYDEN, L. H., WANG, E. KING, R., and, FENG, S., (EAPS, MIT, Cambridge, MA 02139, bcburch@mit.edu; CHEN, Z., and LIU, Y., Chengdu Institute of Geology and Mineral Resources, Chengdu, P. R. China.

Our studies of active tectonism in the eastern part of the Tibetan plateau indicate that processes of crustal thickening and elevation of the plateau are related to the complex structures that transfer deformation between strike-slip, shortening and extension at scales of 1000 to 100 km. We divide active tectonism of the eastern Tibetan plateau into three areas with different structural activity. A northern region, the Qilian Shan and Qaidam basin bounded on the south by an east-trending belt the Qinling-Kunlun deformational belt, rotates clockwise and moves NE transferring motion on the Altyn Tagh fault zone into shortening. A central region, the Longmen Shan-Sichuan Basin bounded on the south by the Xianshuihe-Xiaojiang fault system, deforms at a slow rate (< 5mm/yr) and shortening within this region is too small to form the high plateau to its west. A southern region, south and west of the Xianshuihe-Xiaojiang fault system and extending into Indochina and Burma, rotates clockwise around the eastern Himalayan syntaxis. It does not behave as a rigid fragment, but contains smaller fragments which transfer strike-slip motion into shortening and extension. Present differences in structural styles demonstrate contemporaneous deformation within the eastern part of the Tibetan plateau is not uniform within the India-Eurasia collisional system. Although less well established, we suggest that similar differences in structural style, separated by different boundaries, have existed throughout the evolution of the Tibetan plateau as the eastern Himalayan syntaxis migrated northward. The present morphology of the plateau gives the appearance of uniform crustal processes, but, this may be related to Tibetan crustal rheology and decoupled flow in mid or lower crust. Differences in topography on the plateau related may be partly compensated by changes in thickness and flow in the lower crust.

3:30 PM Klemperer, Simon L.

MID-CRUSTAL REFLECTOR TRUNCATING THE INDIA-ASIA SUTURE, AND MAGMA BENATH THE TIBETAN RIFT SYSTEM: RESULTS FROM PROJECT INDEPTH WIDE-ANGLE SEISMIC DATA.

MAKOVSKY, Y., Department of Geophysics, Stanford University, CA 94305-2215, yizhaq@geo.stanford.edu; KLEMPERER, Simon L., Department of Geophysics, Stanford University, CA 94305-2215, klemp@geo.stanford.edu; RATSCHBACHER, L., Institut fuer Geologie, Universitaet Wuerzburg, D-97070 Wuerzburg, Germany, l.ratschbacher@rzbox.uni-wuerzburg.de; and Project INDEPTH Team.

In Project INDEPTH (INternational Deep Profiling of Tibet and the Himalaya), we recorded explosive sources across the Tsangpo suture (TS). A bright, continuous, 90-km-long band of reflections (Tsangpo suture reflection, TSR), is imaged dipping c. 4° north at c. 20 km depth beneath the outcrop position of the TS. Additional profiles constrain the TSR to be at least 80 km in east-west extent, suggesting it is not related to recent east-west extension in southern Tibet that has formed grabens only 20 km wide. Refracted phases from the TSR imply a seismic vel ocity of c. 7 km/s, so we suggest it may be a Tethyan ophiolite underthrust to mid-crustal depth during India-Asia collision. If so, the TSR represents the TS which is therefore sub-horizontal in the mid-crust.

Reflected and refracted phases at offsets of 200 to 300 km from the top of the Indian crust (Main Himalayan Thrust, MHT) and from the Moho (PmP, Pn) imply a relatively flat Moho with a velocity of 8.1 km/s at a depth of 75 to 80 km beneath the TS and shows that the MHT continues north to, at least, about 50 km south of the TS.

A discontinuous band of 'bright-spot' reflections was imaged by the INDEPTH CMP profile at c. 6 s (c. 15 km depth) beneath the Yangbajain rift, an area of intense geothermal activity. The brightest reflections recorded by us in the rift are P-to-S-wave converted reflections off the bright-spots at offsets between 20 and 50 km, or incidence angles c. 30 to 60 degrees. P-to-S converted phases are stronger than P-wave reflections at these incidence angles only when they reflect at a solid-fluid interface, so we suggest that the 'bright-spot' reflections originate at magma bodies.

3:45 PM Spencer-Cervato, Cinzia

CHEMOSTRATIGRAPHIC CORRELATION OF LOW- TO HIGH-GRADE METAMORPHOSED SEDIMENTS IN THE HIMALAYA OF PAKISTAN AND INDIA

SPENCER-CERVATO, Cinzia, University of Maine, Dept. of Geological Sciences, 5764 Sawyer Research Center, Orono ME 04469, cinzia@maine.maine.edu; and SPENCER, David A., Institute of Geology, Swiss Federal Institute of Technology (ETH), 8092 Zurich, Switzerland, DASpencer@ erdw.ethz.ch.

The Tethyan Himalayan sediments can be traced from India into Pakistan, firstly as a distinctive unmetamorphosed unit and then as a metamorphosed cover to the Higher Himalayan Basement. This unit, therefore, provides a unique metamorphic record of the Himalayan continental collision and can be used to map compositional changes related to progressive metamorphism.

Unmetamorphosed sediments of Carboniferous to Triassic age in the Zanskar region of India are intercalated with Permian volcanic rocks of the Panjal Traps. This sequence is now proved to correlate with the equivalent high-pressure metasediments and metavolcanics from Kaghan Valley in Pakistan. Oxygen and carbon isotope analyses of unmetamorphosed carbonates and marbles were used, along with other stratigraphic and geochemical methods, to constrain this correlation.

SESSION 140, 1:30 PM

Wednesday, October 30, 1996

Tectonics V: Asian Tectonics

CCC: C102-104-106

1:30 PM Dilek, Yildirim

STRUCTURE AND GEOCHRONOLOGY OF THE INNER–TAURIDE BELT, SOUTH–CENTRAL TURKEY, AND ITS TECTONIC EVOLUTION

DILEK, Yildirim, Dept. of Geology, Miami University, Oxford, OH 45056; **HACKER, Bradley R.**, Dept. of Geology, Stanford Univ., Stanford, CA 94305; and **MILLER, Jonathan S.**, Dept. of Geology, Univ. of North Carolina - Chapel Hill, NC 27599.

Tectonic units along a N-S trending geotraverse across the Inner-Tauride belt in south-central Turkey include, from south to north, the Mersin ophiolite, Bolkar massif, Alihoca ophiolite, Ulukisla basin/arc, and the Nigde metamorphic massif. The Mersin and Alihoca ophiolites contain the upper mantle and lower crustal units of a Cretaceous Neo-Tethyan oceanic lithosphere and are intruded by mafic dike swarms of an arc tholeiite affinity. $^{40}Ar/^{39}Ar$ hornblende dating of amphibolites in the metamorphic soles of the Mersin ophiolite and an ophiolitic klippe near the peak of the Bolkar Mountains gave cooling ages of 91 Ma, whereas the mafic dike swarms from both ophiolites revealed plateau ages between 91 and 88 Ma. The Bolkar massif represents part of the Tauride carbonate platform and forms an E-W trending, northward overturned anticlinorium composed of Paleozoic to U. Cretaceous carbonates with siliciclastic and volcanic rock intercalations. Zircon dates from the Horoz granite intruding the Bolkar massif are reversely discordant and give $^{206}Pb/^{238}U$ ages around 56.1 Ma. The Alihoca ophiolite and the Bolkar massif are unconformably overlain in the north by the latest Cretaceous–Tertiary sedimentary, volcanic, and volcaniclastic rocks of the Ulukisla basin. The lowermost flysch units of the Ulukisla basin are intruded by shallow-level plutons ranging in composition from granite, monzonite, to syenite. $^{40}Ar/^{39}Ar$ muscovite dating of a granitic pluton gave a plateau age of 55.7 Ma. These plutons together with the andesitic to trachy-andesitic volcanic rocks in the Ulukisla basin constitute an early Tertiary island arc complex. The Nigde metamorphic massif north of the Ulukisla arc represents a core complex and is part of the larger central Anatolian crystalline complex (CACC). Our interpretation of the available data suggests that the Alihoca and Mersin ophiolites are part of an ophiolitic nappe derived from a Neo-Tethyan branch that evolved between the Tauride platform in the south and CACC in the north. Initial displacement of oceanic crust and the initiation of an intraoceanic subduction zone within this Neo-Tethyan basin occurred around 92. Emplacement of the ophiolite nappe onto the Bolkar massif occurred in the Late Cretaceous and resulted in deformation and crustal thickening in the underlying carbonate platform. The Ulukisla arc complex and its basin developed in the upper plate of the north-dipping subduction zone in the diminishing Neo-Tethys. Emplacement of the Horoz granite into the Bolkar massif in the downgoing plate might be related to partial melting of the thickened continental crust. Docking of CACC to the Ulukisla arc was completed by the Oligocene and was followed by the rapid unroofing of the Nigde metamorphic massif in the Miocene.

1:45 PM Yilmaz, Yücel

GEOLOGY AND TECTONIC EVOLUTION OF THE PONTIDES

Yücel Yılmaz, Okan Tüysüz, Erdinç Yiğitbaş, Ş.Can Genç and A.M. Celal Şengör
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The Pontides as an orogen may be divided into three main sectors; the East Pontide, the Central Pontide and the West Pontide. Each of these represents an amalgamated tectonic mosaic consisting of the remnants of oceanic, continental and and island-arc segments.

The East and West Pontide tectonostratigraphic units meet in the Central Pontide region where they structrally intermixed and form a tectonic knot. In this tectonic mosaic there are Cimmerian continental fragments and the Palaeo-Tethyan oceanic assemblages.

The Pontides recorded the Cimmerian and Alpide orogenic events. The Cimmerian orogenic phase resulted from the elimination of Paleo-Tethys and her dependency which is known as the Karakaya marginal basin that existed during the Triassic. The Paleo-Tethyan ocean was located to the north of the Cimmerian continent which form the basement of the Pontides. During the closure of the Paleo-Tethys, an andean-type magmatic belt was developed on the Cimmerian continent due to the southward subduction of the Paleo-Tethyan ocean floor. During this period the Neo-Tethys began to open possibly as a back-arc basin behind the Cimmerian continent in the Liass. In the Dogger whiles the collision between the Scythian platform of Laurasia and Cimmerian continent took place in the north and eliminated most of the Paleo-Tethys ocean floor, the Neo-Tethys continued to grow in the south.

The late Cretaceous witnessed the elimination of the Neo-Tethys due to its northward subduction, under the Pontides. This created a new active continental margin arc. The closure of the Neo-Tethys resulted in the collision between the Pontide arc and the Tauride-Anatolide platform. Its lingering affects continued till the Middle Eocene. The present mountain began to elevate as a giant horst block during the late Miocene.

2:00 PM Pană, Dinu

STABLE AND RADIOGENIC ISOTOPE STUDY OF LITHOTECTONIC ASSEMBLAGES FROM THE APUSENI MOUNTAINS, ROMANIA

PANĂ, Dinu, ERDMER, Philippe, HEAMAN, Larry, CREASER, Robert A.,
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The Apuseni Mountains occupy the inside bend of the Carpathian orocline. Their basement rocks comprise medium- and low-grade metamorphic assemblages and associated igneous rocks. Low-grade rocks display a large component of non-coaxial strain; their distribution and isotopic ages outline two major zones of Alpine strain concentration and fluid-rock interaction: the Highiş-Biharia shear zone (HBSZ), from the Pannonian Basin in the southwest to the Transylvanian Basin in the northeast, and the Trascău shear zone (TSZ) along the Apusenis' eastern boundary. The evolution of the basement rocks is constrained by $^{40}Ar/^{39}Ar$ data from metamorphic rocks and U/Pb zircon data from granites in several assemblages. Non-retrograded medium-grade assemblages record post-metamorphic cooling between c. 300 and 315 Ma, following a regionally penetrative Late Variscan overprint. Low-grade assemblages yielded synkinematic muscovite and whole-rock phyllonite ages of c. 120 to 100 Ma, indicating Early- to Middle Cretaceous tectonism in the HBSZ and TSZ. Zircons from granitic rocks yielded Paleozoic emplacement/crystallisation U/Pb ages ranging from c. 500 to 266 Ma. Sm-Nd isotopic data from both metamorphic and associated igneous rocks indicate crustal residence ages ranging from 1.7 to 1.3 Ga. An age of 155 Ma obtained from the Savirsin granite, previously considered to be Cretaceous, is interpreted to date subduction magmatism. Stable-isotope and fluid-inclusion data from the low-grade rocks of HBSZ indicate alteration of igneous values by a chemically evolved fluid of surficial origin. We suggest that the carbonate lenses developed by metamorphic differentiation during Alpine shearing of an older igneous and adjacent gneissic crust and grew by metasomatism during progressive exhumation.

The tholeiitic-calcalkaline suite of the southern Apuseni Mountains, previously considered as the main remnant of the Tethys Ocean, is interpreted to record a Middle Jurassic transtensional zone in ancient European crust, and the Neogene volcanism commonly interpreted to be subduction-related is reinterpreted as the result of postorogenic gravitational collapse.

2:15 PM Gregory, Robert T.

TECTONICS OF THE ARABIAN MARGIN ASSOCIATED WITH THE EMPLACEMENT OF THE OMAN OPHIOLITE, NE SAIH HATAT

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In contrast to other parts of the autochthonous continental margin exposed in the Oman Mountains, northeastern Saih Hatat suffered high pressure blueschist to eclogite facies metamorphism accompanied by intense deformation involving nappe development. The recognition of a major low angle detachment fault within this structural pile greatly simplifies the interpretation of the structure of this zone. The upper plate rocks consist of the pre-Permian to Jurassic rocks folded into large recumbent nappe structures which close to the south and have amplitudes of at least 10 km. The major upper plate nappe has a fold axis which is doubly plunging trending to the east. High strain zones develop in the upper plate as the boundary with the detachment is approached. The lower plate rocks are exposed to the east in a window at As Sifah as well as in windows traversed by Wadi Hul'w and Wadi Meeh to the west. The stratigraphy of the lower plate rocks is similar to the upper plate involving metamorphosed equivalents of the Amdeh Group, Hijam and Saiq formations. Metabasic rocks locally achieved eclogite facies in the easternmost window at As Sifah. The lower plate rocks have suffered uniformly higher strain. The largest lower plate nappe structures now exposed have amplitudes on the order of 5 km and may be parasitic to still larger structures. Fold axes are parallel to the regional lineation which strikes NNE. Sense of shear indicators yield a transport direction of south over north in the lower plate. Strain rates were high enough to support the development of sheath folds, shear bands, and boudinage. The boudins develop over a large range of scales (from the microscale up to kilometer-sized blocks). All of the As Sifah area eclogite facies metabasalts are preserved in kilometer-scale megaboudins indicating that the progressive deformation continued beyond the peak of metamorphism. The stretching lineation within the upper and lower plates, Hatat schist (the basement), and metamorphic sole of the ophiolite is consistently SSW to NNE suggesting that the high pressure metamorphism of Saih Hatat is related to the ophiolite obduction.

2:30 PM Baig, M. S.

PALEOZOIC TECTONICS OF THE INDIAN PLATE, NORTHWEST HIMALAYA PAKISTAN

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In the northwest Himalaya of Pakistan, the rocks of the Indian plate record evidence for Paleozoic tectonics. In Early Paleozoic, the Early to Middle Cambrian platform shallow water marine deposition of the Abbottabad Group, Sherwan Formation, and Muzaffarabad Formation unconformably occurred on the Late Proterozoic Hazara, Tanawal, and Dogra Formations, respectively. It was followed by the Ordovician orogeny which accompanied 466±2-434±1 Ma (Ar/Ar Hb and Bt dates) amphibolite facies metamorphism and 500-450 Ma

ABSTRACTS WITH PROGRAMS VOL. 28, NO. 7 1996 ANNUAL MEETING ISSN 0016-7592

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