Conditions for melting, determined from coexisting garnet-hornblende-plagioclase and garnet-hornblende assemblages, indicate pressures of 6.5 kbars and temperatures of 700°C. These conditions lie along the experimentally-derived muscovite-dehydration boundary, as also seen in the field.

The melts are not those that fed the Idaho batholith. They may have formed at about the same time but at a somewhat shallower level than those of the batholith.

BTH 91 Sirbescu, Mona

THERMOTECTONIC EVOLUTION AND CRUSTAL ANATEXIS IN THE TRANS-HUDSON PROTEROZOIC OROGEN, BLACK HILLS, SOUTH DAKOTA

SIRBESCU, Mona, NABELEK, Peter, and LIU, Mian, Dept. of Geological Sciences, University of Missouri, Columbia, MO 65211

The crystalline terrane exposed in the Black Hills represents the southernmost portion of the Proterozoic Trans-Hudson orogen. Early Proterozoic metasedimentary rocks, deformed and regionally metamorphosed at 1.76 Ga above staurolite isograd, were uplifted for several kilometers and cooled to 300-500°C (Holm et al., Tectonics, 1997) prior to the post-tectonic intrusion of the 1.71 Ga peraluminous Harney Peak Granite (HPG). Contact metamorphism reached the second sillimanite isograd, at a pressure between 3.5 and 4.5 kbar. Thermal-rheologic modeling, constrained by geological and geochronological data for Proterozoic metamorphic rocks and leucogranites in the Black Hills, is used to investigate (1) the dynamic links between crustal shortening, extension, and crustal anatexis and (2) the cooling history and unroofing rate during extension.

Numerical modeling shows that post-thickening thermal relaxation and radioactive heating alone cannot account for the middle crust partial melting of metasedimentary rocks, therefore additional heat sources are required. Shear heating generated during progressive thrusting, computed using realistic estimates of shear zone thickness as well as shear stress, rate and duration, may have been a dominant factor in producing temperatures sufficient for muscovite and biotite dehydration melting reactions. The proximity of the metapelite derived, undeformed HPG to major fault lines indicates also the importance shear heating in melt production. Since extensional unroofing was taking place simultaneously and after crustal shortening, at some structural levels melt generation might have been promoted by decompression. The lack of any mantle melt or fluid signature at the exposed structural level, argues against additional mantle heat flux as the major cause of HPG generation. The importance of shear heating suggested in this study is consistent with the common occurrence of peraluminous leucogranites along major thrust sutures in collisional-extensional orogens.

BTH 92 Ustaömer, Timur

TECTONIC-SEDIMENTARY EVOLUTION OF THE N TETHYAN MARGIN IN THE E PONTIDES, NE TURKEY

Timur Ustaömer, Istanbul Universitesi, Jeoloji Bolumu, Avcilar 34850, Istanbul, Turkey, timur@istanbul.edu.tr

Pre-Late Jurassic E Pontides tectonic belt of N Turkey documents multi-stage crustal extension, basin formation and associated magmatism associated with an active margin. Although similar extensional histories for the same period are well documented in the Central and SW Pontides, the E Pontides differ from these by an absence of ophiolites, ophiolitic mélanges and subduction-accretion complexes.

The pre-Jurassic basement of the E Pontides in the Yusufeli area comprises four NE-SW trending tectonic units, seperated from each other by dominantly high-angle shear zones. A thick (> 5 km) sequence of upright, isoclinally folded phyllites, volcaniclastic turbidites and occassional calc-rudites, intercalated with locally pillowed lava flows are exposed in the NW (Irmakyani Group). A fault-bounded sliver of high-grade metamorphics (amphibolites-migmatites) and cross-cutting dykes are exposed in the mid part of the tectonostratigraphy (Demirkent Intrusive Complex). The dykes range in composition from gabbro to plagiogranite (100 % dykes) and cut the foliation of the host rock. The amphibolites crop out only in screens of several tens of metres wide in the dyke complex. A third unit exposed in the SE is a volcanic sequence (the Kinalicam volcanics), made up of pillow lavas and lava breccias with numerous cross-cutting dacitic dykes and associated lava flows. The lava breccias are stratigraphically overlain by shallow marine sandstones. An allocthonous sequence, termed the Karadag Group, is thrust over the above units. The Karadag Group is represented at the base by a sequence of quartz mica schists and metaconglomerates intruded by two-mica meta-granites. The metamorphics are unconformably overlain by fossiliferous black shales and tuffecous sediments, cut by gabbroic intrusions.

The lavas associated with the Irmakyani Basin are of high-aluminum and IAT basalts and andesites. The geochemistry of interbedded volcaniclastic sandstones implies a volcanic arc-type provenance. The extensional dykes were derived from a common source and their geochemical characteristics indicate above subduction zone melt generation, accummulation and fractional crystallisation, with differantiation in a magma chamber in an extensional setting. The Kinalicam Lavas show LIL-element enrichment, Nb depletion relative to LREE and Zr depletion relative to Ti. These are also characteristics of supra-subduction zone lavas.

I hypothesise that the Irmakyani basin represents a Triassic (?) deep-marine basin, constructed on stretched continental crust. The basement of this basin was the Demirkent intrusive complex and the amphibolites. The Kinalicam volcanics are interpreted as marginal eruptive centres. The Karadag Group is interpreted as a preserved sliver of a continental assemblage, adjacent to the basin. The basin was closed prior to Jurassic.

BTH 93 Edwards, M.

SYNKINMATIC MAGMATISM WITHIN SW NANGA PARBAT, PAKISTAN HIMALAYA

SCHNEIDER, D., Lehigh University, Bethlehem PA, EDWARDS, M., KIDD, W., SUNY-Albany, Albany NY, ASIF KHAN, M., NCE-Geology, Peshawar, Pakistan, ZEITLER, P., Lehigh University, Bethlehem, PA, and COATH, C., UCLA, Los Angeles, CA

A general association of young plutonism, deformation, and cooling within Nanga Parbat (NP), Pakistan Himalaya, is clearly recognized and can generally be linked with recent, rapid uplift. Field observations and geochronologic data from SW NP shed light on the relationship between melting and development of a newly recognized major shear zone.

Southwest of NP, a dominantly plutonic, ~5 km thick crystalline sequence forms a continuous, ~30 km long, N-S belt with vertical to steeply E-dipping fabrics. A coarse-, to medium-grained biotite granite (Jalhari granite) grades into granitic and porphyroclastic gneiss due to syn- to post-plutonic deformation. Jalhari leucogranite lenses (10s-100s m) showing little to no sub-solidus deformation are separated by 10s-100s m thick layers of gneiss where deformation of the granite has been localized. Higher strain layers anastamose around the granite lenses and mark reverse faults that climb westward. The granitic gneiss shows significant sub-solidus strain, including S-C porphyroclastic fabric whose shear sense indicates east side (NP) up and over west. Argon biotite cooling ages on the western side of this zone are 20-30 Ma, whereas on the eastern side (towards NP) cooling ages are 6 Ma and younger. Ion microprobe Th-Pb monazite analyses of a deformed, biotite-rich portion of the Jalhari yield ages between ~3 and 9 Ma. Older ages reflect higher Th/U ratios. BSE/SEM images of the monazites indicate some that have a chaotic textural pattern, notably lacking clear core-rim zoning. However, a few texturally homogeneous grains were analyzed; these yielded the youngest of our obtained ages (~3-4 Ma). An undeformed medium grained granite, which is adjacent to, and possibly part of, the Jalhari, yielded monazite Th-Pb ages of 12 Ma. For the Jalhari, we purpose: 1) initial pulse(es) intruded and crystallized as young as ~12 Ma, 2) ongoing synkinematic magmatism (as represented by the patchy monazite grain textures indicative of multi-stage growth history) resulted in further pulses that juxtaposed deformed and undeformed portions of the granite, and 3) final crystallization at 3-4 Ma. The lower age limit is consistent with our cooling ages inboard and east of the Jalhari granite belt.

BTH 94 Stockstill, Karen R.

EVOLUTION OF THE BURROUGHS MOUNTAIN LAVA FLOW, MOUNT RAINIER, WASHINGTON

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The Burroughs Mountain lava flow of Mount Rainier is a large volume (3.4 km3) andesitic lava flow, which conformably overlies andesitic block and ash-flow tuffs that reach thicknesses of 350 meters. The lava erupted non-explosively 496,000 years ago on the northeast side of Mount Rainier and extends 11 km in length. The block and ash-flow deposits include both non-vesiculated and vesiculated clasts. The lava flow contains rare quenched magmatic inclusions as well as more common coarser-grained gabbroic to dioritic inclusions of probable cumulate origin. The block and ash-flow tuff and the lava flow are chemically similar, despite different eruptive styles, and range from 56.7 to 62.2 wt. % SiO2 and 2.8 to 4.0 wt. % MgO. The major element of both of these deposits vary systematically with linear decreases in CaO, TiO2, and FeOt with respect to decreases in MgO, and an increase in SiO2 - trends consistent with fractional crystallization. However, incompatible trace elements are not well correlated with MgO. For example Rb varies from 21 to 39 ppm at a nearly constant MgO concentration (3.5-4.0%), whereas Zr varies from 127-177 ppm for the same MgO concentration. Fractional crystallization of a single parent magma cannot produce these changes. In the block and ash-flow deposit the vesiculated clasts are slightly more mafic than the non-vesiculated clasts, ranging from 56.4 to 58.2 wt. % SiO2 and 4.2 to 4.5 wt. % MgO. In the lava the inclusions are much more mafic than their host, ranging from 55.1 to 56.4 wt. % SiO2 and 4.6 to 7.5 wt. % MgO. The quenched inclusions result from influx of new magma into the magma chamber where the magma was quenched, preventing mixing. The coarser inclusions were probably cumulates exhumed from the magma reservoir margins, but need not be cognate. Neither fractional crystallization nor two-component mixing can produce the scatered variation of the incompatible trace elements - additional processes such as multiple parent magmas, variations in source compositions, and/or assimilation are required.

BTH 95 McGinnis, Cathleen E.

EVOLUTION OF THE SUBCONTINENTAL MANTLE IN NORTHERN VENEZUELA: UNRAVELING MANTLE EVOLUTION IN A COLLISIONAL REGIME

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Northern Venezuela has been in oblique collision since the Eocene with the southern boundary of the Caribbean Plate producing an indistinct boundary zone and only occasional, localized magmatism. One area in northeastern Venezuela, the NE-SW trending Falcón Basin, contains mantle-derived, xenolith-bearing alkali basalt intrusives. The Falcón Basin formed during Eocene to Oligocene in a tensional tectonic regime facilitated by dextral offset along the east-west trending Oca, Cuiza, and San Sebastian fault systems. Basin subsidence was accommodated by transcurrent and normal faulting, which resulted in the formation of a rhomb-shaped pull-apart basin. Thinning of the crust in the central Falcón Basin resulted in several features that were conducive to melt formation and intrusion: (1) thinning of the lithosphere decreased the overburden on the upper mantle, thereby decreasing the pressure in the underlying upper mantle, (2) faulting in the basin weakened the crust and provided conduits for efficient, fast transport of magma, (3) weak contacts between lithologic units of the basin were ideal for the creation of sills and plugs. In our study, fresh whole rock samples were analyzed by 40Ar/39Ar; the results conclude that there were at least three distinct episodes of magmatism at 19.6+/-0.1Ma, 18.5+/-0.3Ma, and 15.4+/-0.5Ma. The events generally young to the northeast. Chemistry of the intrusives can be correlated with age and geography. For example, Nd and Sr isotopic become less radiogenic from SW to NE. Trace element ratios (e.g., Zr/Hf, Zr/Nb, etc.) generally increase to the NE, whereas Rb/Ba decreases. This chemical and age progression is consistent with rifting associated with the passing of the Caribbean plate west to east in this region during the Miocene. However, the situation is complicated by the presence of a shallow (17 degrees to N160E) subduction zone beneath the Falcón Basin (Perez et al., 1997, JGR 102, 17,875) which was initiated during the Eocene. The source(s) of the Falcón Basin alkali basalts appear to have been metasomatized by fluids derived from the downgoing slab. Chemical data from the basalts and xenoliths allows the evolution of the upper mantle in this area to be traced. Continuing studies of mantle-derived igneous material across northern Venezuela will allow an evaluation of mantle heterogeneity and evolution in an oblique collisional environment.

BTH 96 Harrison, T. M

THE RELATIONSHIP BETWEEN LEUCOGRANITES AND THE STDS IN THE RONGBUK VALLEY, TIBET

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The Southern Tibetan Detachment System (STDS) is a series of gently N-dipping normal faults that can be traced along much of the length of the Himalaya. In the Rongbuk Valley, immediately north of Mt. Everest, the STDS is represented by the Qomolangma detachment. The map relationship between Tertiary leucogranites exposed in the STDS footwall along the eastern wall of the Rongbuk Valley and the master fault has been variously portrayed as 1) sills that are entirely subparallel to the STDS (Burg, 1983), 2) sills as in (1) and the discordant Rongbuk granite that does not cut the trace of the detachment (Burchfiel et al., 1992), and 3) sills as in (1) and emplacement of the Rongbuk granite across the detachment into the overlying Tethyan metasediments (Hodges et al., 1998). Each of these scenarios carries different implications regarding the significance of the age of the leucogranites with respect to the tectonic evolution of the STDS. Previous U-Pb dating of Rongbuk area sills that were sampled in situ yielded crystallization ages between 17-14 Ma (Scharer et al., 1986; Hodges et al., 1998) whereas a float block from near Rongbuk village yielded a crystallization age of 22 Ma (Harrison et al., 1995). In order to select between the three interpretations described above, we have re-mapped the region adjacent to Rongbuk village. The footwall of the Qomolangma detachment is defined by a >800-m-thick zone of mylonitic schists, calcsilicates, marbles and leucogranite sills and dikes. The trace of the detachment is planar and oriented N30°W/14°NE. No leucogranite bodies cut the detachment fault in the mapped area and no discordant granite pluton was observed. Two generations of leucogranites are recognized based on crosscutting relationships and their degree of deformation. At lower structural levels, mylonitized sills are cut by undeformed leucogranite sheets

11:00 AM Lovera, Oscar

A POSSIBLE METHOD TO EVALUATE THE BAJA-BC CONNECTION: DETRITAL K-FELDSPAR CLOSURE AGE DISTRIBUTIONS FROM FOREARC STRATA

GROVE, Marty and LOVERA, Oscar, Dept. of Earth & Space Sciences, UCLA, Los Angeles, CA 90096, lovera@oro.ess.ucla.edu Kimbrough, D.L., Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182.

Analysis of detrital mineral closure age distributions is a useful tool for determining genetic ties between potentially correlative strata. We have identified along-strike variations in K-feldspar closure age systematics in forearc sedimentary rocks formed outboard of the 120-90 Ma Peninsular Ranges batholith (PRB) in Baja and southern California that may permit evaluation of their hypothesized affinity to tectonically displaced strata of similar age in British Columbia (e.g., Nanimo and Methow basins of the Insular Superterrane). Our approach involves a statistical representation of concurrent intrusion, denudation, and erosion facilitated by a simple thermo-kinetic model. While its primary goal is to deduce basement denudation histories from detrital closure age systematics, the results may be sufficiently diagnostic to establish correlations. Localities astride the more deeply denuded northern PRB (e.g., San Diego, Santa Ana Mountains) yield age distributions that require ~0.5 mm/yr. batholith denudation from the time of PRB emplacement to the Late Campanian. The youngest closure ages from a given stratigraphic interval generally overlap depositional ages while maxima in the distributions predate sedimentation by only 5-10 m.y.. The oldest closure ages are generally <100 Ma (i.e., late batholithic). In contrast, more limited results from the Vizcaino Peninsula indicate substantially slower (~0.25 mm/yr) Campanian-Maastrictian denudation of the southern PRB, consistent with the shallower basement erosion depths at this latitude. The youngest closure ages predate deposition of Campanian to Maastrictian sediments by 15-20 m.y. while distribution maxima overlap with late stage batholith intrusion (100-90 Ma). While the southern PRB results are similar to those obtained from the southern Sierra Nevada forearc, the abundance of pre-Late Cretaceous K-feldspar detrital closure ages exhibited by the latter are not observed for the PRB. Comparable measurements performed with materials from the Nanimo and Methow basins may very well reveal whether these rocks came from either the northern or southern PRB forearc or could alternatively suggest a disparate origin.

11:15 AM Mahoney, J. Brian

COMPARITIVE EVOLUTION OF CRETACEOUS BASINS IN BAJA CALIFORNIA, MEXICO AND BRITISH COLUMBIA: IMPLICATIONS FOR TERRANE TRANSLATION

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Comparative analysis of Cretaceous sedimentary sequences in Baja California and southern British Columbia constrain models of terrane translation and paleogeographic reconstruction along the western Cordilleran margin during the Late Cretaceous. Paleomagnetic data suggest that Upper Cretaceous Rosario and Valle Group strata of Baja were deposited approximately 1200+/-500(?) km south of their current position, while coeval strata of the Nanaimo and Methow basins of the Insular Superterrane in British Columbia were deposited >3000 +/- 500 km south of their present latitude. Paleogeographic reconstructions based on paleomagnetic data therefore indicate that the Insular superterrane, with its associated Cretaceous strata and Jura-Cretaceous plutonic rocks likely occupied a position south of the Sierra Nevada Batholith and north of the Peninsular Ranges Batholith in the mid-Cretaceous. This reconstruction implies that the Nanaimo and Methow basins formed along strike immediately to the north of the depositional site of the Rosario and Valle Groups of Baja California.

The Valle, Rosario, and Nanaimo Groups display first-order similarities, including timing of subsidence, sediment type, sedimentation rates and tectonic setting. Each basin formed in a forearc position and is dominated by volcanoplutonic debris derived from a partially dissected arc to the east. Significant second-order differences, including conglomerate clast compositions, subsidence mechanisms, and the age and petrologic character of the source regions do not clearly support paleogeographic reconstructions required by paleomagnetic data. Recognized differences require along-strike variability in the timing and nature of magmatism, country rock compositions, and forearc basin evolution. The Methow basin, which currently occupies a backarc position relative to the Coast Plutonic Complex, received both easterly derived volcanoplutonic detritus and westerly-derived chert lithic debris throughout the late Albian and Cenomanian. Structural imbrication of the Methow basin and the Insular superterrane occurred prior to proposed large-scale translation, and the complex, two-sided evolution of the Methow basin constrains both the nature of the source regions and the paleogeographic position of the basin during Albian and Cenomanian time. Further, the Insular superterrane must be displaced from its original position south of the Sierra Nevada batholith without collecting any remnants of the southern miogeocline from western Mexico or leaving any obvious fragments of distinctive Wrangellian basement in its wake.

11:30 AM Johnsson, Mark J.

AN APTIAN-ALBIAN VOLCANIC ARC IN NORTHEASTERN ALASKA? GEOCHEMICAL EVIDENCE FROM SANDSTONES OF THE KANDIK RIVER TERRANE

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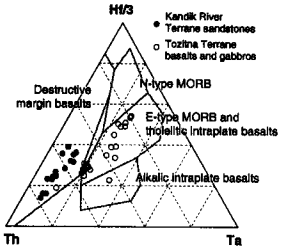
The Kandik River terrane, east-central Alaska, contains a thick Cretaceous sequence that records the transition from passive margin sedimentation to synorogenic sedimentation associated with the accretion of outboard terranes to parautochthonous North America. Coarse volcaniclastic detritus in the Aptian-Albian Kathul Graywacke was originally believed to reflect the accretion of oceanic rocks (Tozitna and related terranes). Volcanic lithic fragments in the unit are dominantly andesitic, however, and trace element data more closely resemble arc-derived sources than either typical oceanic crust or ocean plateau basalts of the Tozitna terrane. The chondrite-normalized REE distributions of the Kandik River terrane sandstones shows moderate overall LREE enrichment and small Eu anomalies. They show a greater LREE enrichment than samples from the Tozitna terrane, but very similar REE patterns to the model andesite of Taylor and McLennan (1985). On the Hf-Th-Ta diagram of Wood (1980) Tozitna terrane rocks plot mostly in the E-type MORB field, whereas the Kandik River sandstones plot distinctly away in the destructive margin basalts field. Trace element data thus are consistent with the interpretation that the volcaniclastic detritus in the Kandik River terrane sandstones was derived from an evolved andesitic source, such as an oceanic island arc, and not from primitive basalts and gabbros of the Tozitna terrane.



Unambiguous mid-Cretaceous island arc rocks are absent from northeastern Alaska. The late Jurassic to early Cretaceous Koyukuk arc, which was far to the west of the Kandik River terrane in Aptian-Albian time, was probably deeply eroded and is not a likely source of coarse clastic detritus. A previously unreported and now-eroded island arc thus appears to be the most likely source for the Kathul Graywacke. This arc must have been nearby and west of the Kandik River terrane, and could have overlain granitic rocks of the Ruby terrane or oceanic crust of the Tozitna terrane.

SESSION 154, 08:00 AM

THURSDAY, OCTOBER 29, 1998

T26. ROLE OF PARTIAL MELTING DURING EVOLUTION OF CONVERGENT OROGENIC BELTS (POSTERS)

MTCC Hall E

BTH 89 Dorais, Michael J.

THE PETROGENESIS AND EMPLACEMENT OF THE NEW HAMPSHIRE PLUTONIC SERIES

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The New Hampshire Plutonic Series (NHPS) consists of four magmatic suites produced during the Acadian Orogeny. The syntectonic Bethlehem Gneiss (BG), Kinsman Quartz Monzonite (KQM), and Spaulding Quartz Diorite (SQD) were followed by the post-tectonic Concord Granites. It has previously been suggested that the NHPS resulted from anatexis of the Central Maine terrane (CMT) metasediments because of anomalous enrichment in U that precipitated in an anoxic basin.

Several lines of evidence present difficulties with this model. 1) Only some of the formations of the CMT are U-rich and the KQM has compositions that are incompatible with derivation from these metasediments. 2) The KQM magma reached 900° C which would require an extremely high geothermal gradient, the source of which may have been mantle derived as indicated by the presence of mafic enclaves in the Meredith Granite of the Winnipesaukee pluton. 3) The stable isotopic compositions of many Concord Granites are incompatible with sediments deposited in an anoxic basin. 4) The Winnipesaukee pluton of the SQD contains mafic rocks with compositions indicative of mantle input, either in the form of mafic magmas, or at minimum, mantle heat to melt mafic source rocks. 5) The Winnipesaukee pluton contains magmatic epidote which required intratelluric crystallization at depths below the CMT decollement.

It is proposed that the three syntectonic members of the NHPS ascended along the Central New Hampshire Anticlinorium which was the sight of a dorsal or pop-up zone during the orogeny. The low T, felsic KG may have been produced along the thrust planes of the Acadian orogeny, migrated up the dorsal zone and carried westward in nappes. The KQM followed the BG, migrating up the dorsal zone also to be carried to the west. The decrease in deformation of the KQM compared to the BG indicates that it did not experience the same degree of tectonism and is therefore younger than the BG. The more mafic magmas of the SQD, being the most dense of the NHPS, were the last magmas up the dorsal zone. These were carried both to the west and east in nappes that verged in opposite directions. Finally, the Concord Granites were the result of crustal thickening during the orogeny and on average, were emplaced approximately 50 Ma after tectonism. These plutons lack the structural controls on emplacement of the earlier NHPS and were therefore randomly emplaced across the orogen.

BTH 90 Schafer, Carl M.

PARTIAL MELTING OF QUARTZOFELDSPATHIC GNEISS IN RESPONSE TO DEHYDRATION OF MUSCOVITE IN PELITIC SCHIST, NORTHEASTERN BORDER ZONE OF THE IDAHO BATHOLITH, MONTANA

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Sillimanite-grade metamorphism of pelitic schist in the northern Bitterroot Range, MT caused dehydration of muscovite and release of water. That water caused very little melting in the pelitic schist but did cause melting to form anatectic veins in the structurally overlying quartzofeldspathic gneiss.

Mineralogically the schist, before dehydration, averages about 45% quartz, 25% plagioclase, 20-25% muscovite, and 10% biotite. In spite of abundant muscovite, it lacks orthoclase and produced little anatectic melt. The structurally overlying quartzofeldspathic gneiss averages about 45% quartz, 25% plagioclase, 10% orthoclase, and 15% biotite. It lacks muscovite and sillimanite but contains abundant anatectic veins. We infer that water produced by dehydration of muscovite in the underlying pelitic schist rose into the quartzofeldspathic gneiss causing melting.

ABSTRACTS WITH PROGRAMS VOL. 30, NO. 7 1998 GSA ANNUAL MEETING ISSN 0016-7592

Abstracts *with* Programs

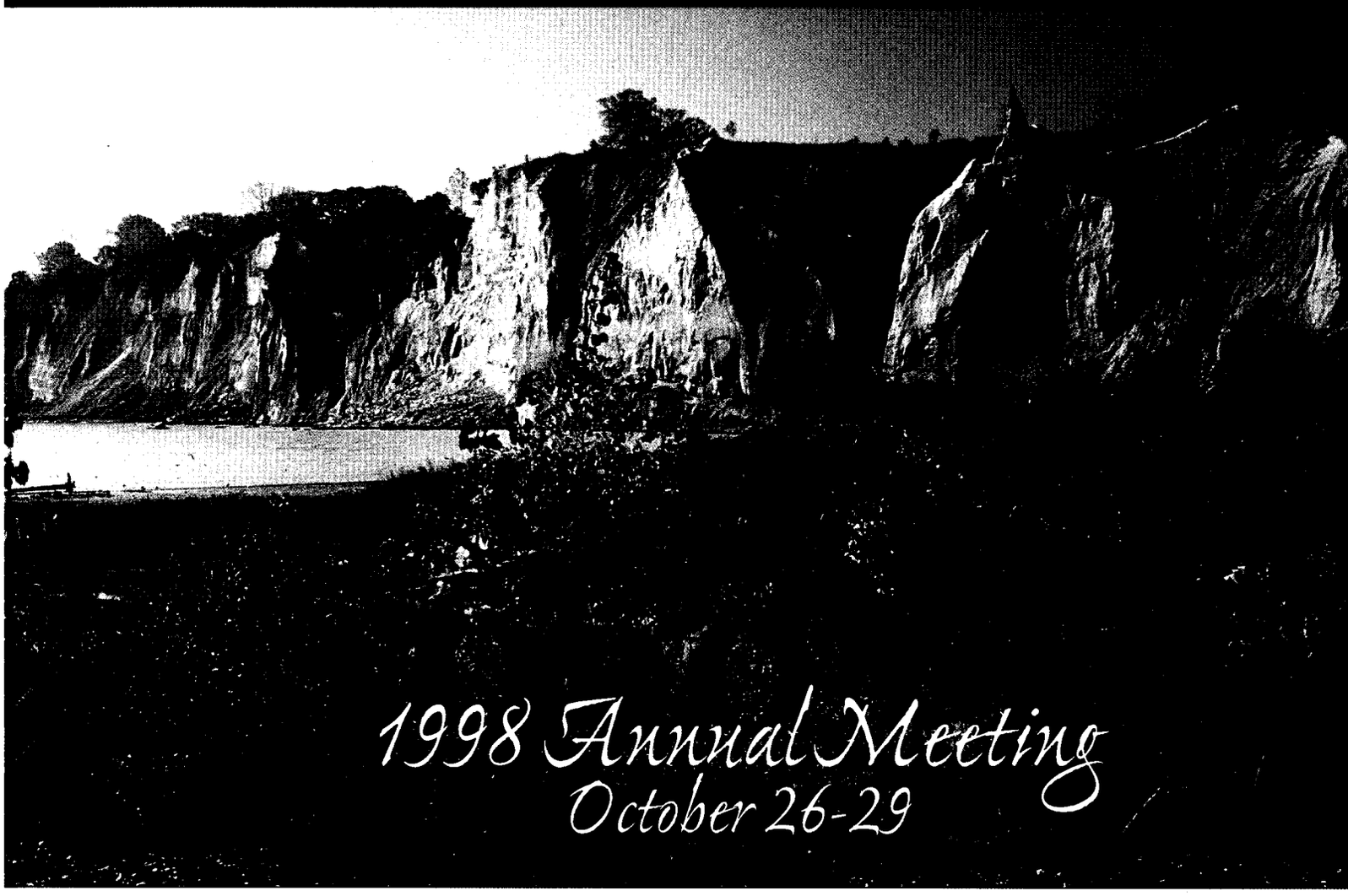

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Photo of Scarborough Bluffs, Ontario by Peter Mvkusz

Assembly of a Continent