HYDROTHERMAL ALTERATIONS OF CLAYS

Tuesday June 22, 2004

Hydrothermal Alterations of Clays Poster Session	
5:00p	**CLAY MINERALOGY OF CORE SAMPLES FROM THE UZON CALDERA, KAMCHATKA, FAR EAST RUSSIA.** Elizabeth R. Hollingsworth[*], and Douglas E. Crowe University of Georgia, Department of Geology, Athens GA 30603-2501
	MESOZOIC HYDROTHERMAL ILLITES IN THE ALTERED SOULTZ-SOUS-FORETS GRANITE, FRANCE. Anja M. Schleicher[*1], Laurence N. Warr[2], Bernd Kober[3], Norbert Clauer[4], and Emmanuel Laverret[3] [1]Geologisch-Paläontologisches Institut der Universität Heidelberg, INF 234, 69120 Heidelberg; [2]Centre de Géochimie de la Surface (CGS/EOST) 1 rue Blessig, 67084, Strasbourg, France; [3]Institut für Umweltgeochemie INF 234, 69120 Heidelberg, Germany; [4]Centre de Géochimie de la Surface (CGS/EOST) 1 rue Blessig, 67084, Strasbourg, France
	PROGRADE CHANGES OF PHYLLOSILICATE MICROSTRUCTURES IN LOW-GRADE PELITIC ROCKS AS CHARACTERIZED BY X-RAY PEAK-PROFILE ANALYSIS AND TEXTURE GONIOMETRY. Chun-Jung Chen[*], Wei-Teh Jiang Department of Earth Sciences, National Cheng Kung University, Tainan, Taiwan
	INTERPLAY OF PROCESSES OF MINERAL TRANSFORMATION, STRAIN RECOVERY AND RECRYSTALLIZATION IN LOW-GRADE PELITIC ROCKS. Wei-Teh Jiang[*1], and Donald R. Peacor[2] [1]Department of Earth Science, National Cheng Kung University, Tainan 70101, Taiwan; [2]Department of Geological Sciences, The University of Michigan, Ann Arbor, MI 48109
	PRELIMINARY STUDIES ON THE SEPARATION OF DIAGENETIC ILLITE FROM DETRITAL MINERALS IN SEDIMENTARY ROCKS FOR Ar ISOTOPE DATING. Zhang Yan[*1], Chen Wen[1,2], and Yang Huining[1] [1]Institute of Geology, Chinese Academy of Geological Science, Beijing, 100037; [2]Institute of Geology and Geophysics, Chinese Academy, Beijing, 100029

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POSTER SESSION

5:00PM

CLAY MINERALOGY OF CORE SAMPLES FROM THE UZON CALDERA, KAMCHATKA, FAR EAST RUSSIA

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Uzon Caldera is an active geothermal area within the Kamchatka Peninsula of Russia. During the summer of 2003, the geochemistry of five active geothermal fields was extensively studied based on the presence of diverse microbial communities, as well as variable geochemical conditions. Within any individual field, pH-Eh-T° (which ranged from 2.2 to 5.9, +255 to -280, and 33 to 94°C, respectively) can vary from pool to pool such that adjacent pools, separated by only meters, can host different mineralized sediments and microbes. To investigate the effects of such variations on the alteration and mineralization of the dacitic gravel through which the geothermal fluids ascend, eight core samples were collected within and adjacent to pools. The cores were sub-sampled on the basis of color and textural differences, reflecting changes in fluid composition and mineralogy. Each sub-sample was size fractionated (<2 μm e.s.d., 2-45 μm, >45 μm) and subsequently analyzed by X-ray powder diffraction.

Elemental sulfur ± opal-A tends to dominate the uppermost portion of most cores (high Eh values) and are either mixed with, or grade downward into zones dominated by kaolin group and mixed layer illite/smectite minerals. In some cores, a sharp redox boundary exists and is characterized by a change in color from gray/green/white at the top to black at the bottom (low Eh). The black sediment is dominated by pyrite ± feldspar and lesser amounts of clay minerals. Results will be presented correlating the measured values of pH, Eh, and temperature, with mineralogy and pool water geochemical analyses.

MESOZOIC HYDROTHERMAL ILLITES IN THE ALTERED SOULTZ-SOUS-FORETS GRANITE, FRANCE

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This study presents petrographic, crystallographic and K-Ar results for hydrothermal illites of the altered Variscan granite of the EPS-1 drilling in Soultz-sous-Forêts, France. The drilling, situated in the Rhine Graben basin, is part of the "hot-dry-rock" project designed to explore geothermal heat as an energy resource. Based on XRD, SEM, HRTEM and K-Ar isotopic investigations of 8 different grain size fractions of four key samples collected from the lower parts of the borehole (below 1550 m levels), we demonstrate a Mesozoic age for illite formation. These well crystallized, pure illite phases are highly concentrated in phyllitic hydrothermal veins, and are present in smaller quantities within the matrix of the pervasively altered granite. The predominant mineral within the veins is an euhedral, $2M_1$ illite polytype variety, formed by both neocrystallization in pore spaces and as direct replacement products of feldspars (both plagioclase and K-feldspar). K-Ar ages of the various grain sizes yield a mixture of ages ranging between 211 and 280 Ma for these illites. In contrast, the host rock granite samples contain an addition generation of fibrous illite crystallites, mainly grown as replacement of plagioclase and minor K-feldspar. Here, the finer fractions (0.2-2 micron) yield a larger age span, ranging between 95 and 195 Ma, whereas the coarser fractions yield ages as old as 255 Ma. A mixture of illite phases of varying ages is also indicated by the complex crystallite thickness distributions (CTDs) determined using the program "MudMaster". The vein-illites reveal a size distribution close to log-normal for the most abundant 2-4 micron fractions. However, for the finer grain sizes, the distributions becomes progressively non-lognormal. In contrast, the illites of the host rock granite yield both asymptotic shapes (> 1 micron sizes) and non-lognormal shapes (< 1 micron sizes). Our results imply, that the late Eocene to the present-day development of the Rhine Graben rift system had no or little effect on the formation of hydrothermal illites at these depths in the Soultz-sous-Forêts granite.

PROGRADE CHANGES OF PHYLLOSILICATE MICROSTRUCTURES IN LOW-GRADE PELITIC ROCKS AS CHARACTERIZED BY X-RAY PEAK-PROFILE ANALYSIS AND TEXTURE GONIOMETRY

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X-ray powder diffraction analysis reveals that the distribution of metapelitic zones in the Tertiary slate belt and pre-Tertiary metamorphic complex of Taiwan are limited by structural and/or stratigraphic boundaries. The variations in phyllosilicate crystallinity indices are continuous at the boundaries where ductile shear zones occur. Slates collected from the ductile shear zones of the Tertiary slate belt and from the schist belt of the pre-Tertiary basement invariably have epizone crystallinity values. The shear-zone slates that either display a set of well-developed disjunctive spaced cleavage or have a zonal crenulation cleavage show better crystallinity than those collected from the neighboring regions. Crystal thicknesses and lattice strains of muscovite and chlorite determined by X-ray peak-profile analysis (Voigt method) increase and decrease respectively with increasing grade in the slate samples. The studied chlorite generally has a crystal thickness similar to that of the intergrown muscovite but shows a better crystallinity, smaller lattice strain, and higher intensity of lattice preferred orientation (LPO), especially in anchizone rocks. The differences are minimal for epizone samples collected from the ductile shear zones and schist belt.

The LPO intensity as measured by X-ray texture goniometry increases with decreasing values of phyllosilicate crystallinity indices, following a linear trend with a few exceptions. In the ductile shear zones, the pole-figure patterns of samples having a zonal crenulation cleavage exhibit an elongated elliptic shape and have moderate LPO intensities nearly identical to those recorded for samples with a disjunctive spaced cleavage. In contrast, the pre-Tertiary slates that have a disjunctive spaced cleavage display circular pole-figure patterns with closely spaced intensity contours and very high LPO intensities (as high as 20 multiples of random distribution) and those that have a discrete crenulation cleavage show highly elongated or two-pole pole-figure patterns with reduced LPO intensities as low as 4 m.r.d. No systematic changes of crystal thickness and lattice strain were observed to be associated with any specific types of cleavage.

The aforementioned result collated with SEM observations collectively imply that the degree of crystallization/recrystallization was significantly enhanced in the ductile shear zones and pre-Tertiary metamorphic complex in which tectonic stress was effective at depths during metamorphic processes. Muscovite and chlorite showed different behaviors in response to tectonic stress and metamorphism with muscovite being able to store higher strain energy under anchizone conditions but recrystallizing rapidly in epizone. The development of disjunctive or crenulation cleavage occurred primarily through dissolution and transfer and/or rotation via grain boundary sliding with minimal lattice distortion and size reduction. The result also suggests that the use of LPO intensity as an indicator of metamorphic progress in low-grade pelitic rocks must consider microstructural changes produced by tectonic stress through time.

INTERPLAY OF PROCESSES OF MINERAL TRANSFORMATION, STRAIN RECOVERY AND RECRYSTALLIZATION IN LOW-GRADE PELITIC ROCKS

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Microstructural evolution of potassium white mica and chloritic minerals in a prograde sequence of pelitic rocks (illite crystallinity indices = 0.17-0.58°Δ2θ) from the Gaspé Peninsula, Québec were investigated by scanning and transmission electron microscope (SEM and TEM) techniques. SEM data show that the microstructures change from a bedding-parallel microfabric with poorly-defined matrix crystal boundaries in the late diagenetic zone to two sets of well-defined fabric elements with two distinct groups of white mica compositions in the epizone.

TEM data show that potassium white mica and chloritic minerals charastically occur as small crystals with high defect densities in late diagenetic rocks. Potassium white mica is dominated by the 1*M*d polytype. Bending of layer packets is common and often associated with dislocations and low-angle boundaries. Elimination of defects is in part due to transformation from corrensite to chlorite. Crystal size increases and defect density and randomness of crystal orientations decrease significantly with increasing grade. Aggregation of medium-size crystals, coalescence of layers associated with dislocations and low-angle boundaries, neoformation of small crystals sandwiched between strained crystals, and embracement of large, defect-free 2*M* by aggregates of small 1*M*d potassium white mica crystals occur in anchizone rocks. Layer bending, dislocations, and low-angle boundaries are much more abundant in potassium white mica than in chlorite. Epizone rocks are dominated by large, defect-free crystals (2*M* muscovite) and high-angle boundaries. Enclosure of medium- to large-sized euhedral crystals within quartz and albite is common.

TEM-measured crystal-size distributions of potassium white mica in samples of different grades have lognormal shapes but with a broad bump on the greater size side of the mode for anchizone rocks. The variance of the logarithms of the crystal dimension increases nearly linearly with increase in mean of the natural logarithms of the crystal sizes. The result appears to be consistent with surface-controlled growth of potassium white mica in open systems, but the studied rocks apparently do not represent isothermal systems affected by identical stress conditions. The data collectively suggest that the size and defect state of Gaspé potassium white mica and chloritic minerals were not governed by simple growth mechanisms but were modified by strain recovery and phase transformations in late diagenetic rocks, and by growth coarsening, layer coalescence (lateral aggregation), neoformation, and polytypic transitions associated with recrystallization in syntectonic prograde metamorphism.

PRELIMINARY STUDIES ON THE SEPARATION OF DIAGENETIC ILLITE FROM DETRITAL MINERALS IN SEDIMENTARY ROCKS FOR Ar ISOTOPE DATING

Zhang Yan[*1], Chen Wen[1,2], and Yang Huining[1]

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The dating of sedimentary rock has in part been hampered by the problem of completely separating diagenetic from detrital illite. Taking the clay minerals collected from the P-T boundary of Changxing area, ZheJiang Province, China as examples, this article introduces the procedure of separation of diagenetic from detrital minerals, including the preparation of suspension and the separation by high speed centrifuge of four samples. All the grain size fractions are analyzed by X-ray diffraction(XRD). XRD shows that impurities, such as quartz, potassium-feldspar, albite, calcite and dolomite, decrease gradually with the decreasing grain size and there are no detectable impurities in the <0.2μm fraction. Especially, the content of mixing I/S in some grain size fractions is 100%, which show that the separation is relatively successful. In addition, we dated some fractions of these four samples by K-Ar dating method and find that the age(~230Ma) of the fractions containing more detrital materials(18-31%) approaches the age of the strata while the age(~190Ma) of the fractions containing little detrital materials(0-5%) are younger than the age of the strata. Of course, these are not the last conclusions and we need further study on the reproducibility of these results and their reasons.