See Pocket 7 For encl.

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February 12, 1986

Dr. D. J. Brooks
Geotechnical Branch
Office of Nuclear Material
Safety and Safeguards
U.S. Nuclear Regulatory Commission
Room 623-SS
Washington, D.C. 20555

Dear Dave:

Please find enclosed the "Radwaste Natural Analog Catalog" by D. G. Brookins. Look over the catalog and call me to discuss any proposed follow-on work related to the catalog.

Sincerely,

Gary

Gary K. Jacobs
Environmental Sciences Division

GKJ/

Enclosure:

"Radwaste Natural Analog Catalog," by D. G.Brookins

cc w/o enclosure:

Office of the Director, NMSS (Attn: Program Support Branch)
Division Director, NMSS Division of Waste Management (2)
M. R. Knapp, Chief, Geotechnical Branch, NMSS
K. C. Jackson, Geotechnical Branch, NMSS
D. G. Brookins, University of New Mexico
G. F. Birchard, Division of Waste Management, RES
A. P. Malinauskas
GKJ File

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WM Project 10, 11, 16
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Distribution:
X D.Brooks

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PDR WMRES EXIORNL
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See B0290 2/12/86
TO' D. J. Brooks
"Radwaste Natural Analog Catalog"

JOURNALS RESEARCHED OR UTILIZED:

AAPG Bulletin
American Journal of Science
American Mineralogy
Bulletin Volcanologique
Canadian Journal of Earth Sciences
Canadian Mineralogist
Chemical Geology
Clay and Clay Minerals
Clay Minerals
Contributions to Mineralogy and Petrology
Earth and Planetary Science Letters
Earth Science
Earth Science Bulletin
Economic Geology
Environmental Geology
GSA Bulletin
Geochemical Journal
Geochemical International (+ Geochemistry)
Geochimica et Cosmochimica Acta
Geological Journal
Geological Magazine
Geological Society of London
Geology (GSA)
International Geology Review
Israeli Journal of Earth Science
Journal of Australian Geology and Geophysics
Journal of Geology
Journal of Geophysical Research
Journal of Petrology
Journal of Research of the USGS
Journal of Sedimentary Petrology
Journal of Structural Geology
Journal of Volcanology and Geothermal Research
Lithos
Marine Geology
Mineralium Deposita
Modern Geology
Mountain Geologist
New Zealand Journal of Geology and Geophysics
Precambrian Geology
Sedimentary Geology
Seismological Society of America
Tectonophysics

TABLE OF CONTENTS

ACTINIDES

1. A) Gen. Cat.--Behavior of actinides in geomedia

   B) Germanov, A. I., 1961, Geochemical and hydrodynamic conditions of epigenetic uranium mineralization in petroleum-water zones: Geochemistry, no. 2, p. 107-120.

   C) Purpose: examine the relationship between uranium deposits and organic matter.

   Methods: literature review.

   Results: uranium precipitation occurs when uraniferous groundwater penetrates petroleum reservoirs. Water Eh drops from 500-250 mv to as low as -400 mv, the uranium is reduced and precipitated. The waters must be enriched in U, possibly up to $n \cdot 10^{-4}$g/liter. Oxidizing conditions are favorable to enrichment.

2. A) Gen. Cat.--Behavior of actinides in geomedia

B) Naumov, G. B., 1961, Some physicochemical characteristics of the behavior of uranium in hydrothermal solutions: Geochemistry, n. 2, p. 127-147.

C) Purpose: examine conditions of uranium ore formation.

Methods: literature review.

Results: CO_2, F, S, Cl, and some form of silica are important components of U-bearing hydrothermal solutions. Temperatures range from 25°C to 300°C, pressures were less than 1000 atm., and the solutions could not have been strongly acid. U may be transported as complicated complex ions, most probably carbonates or fluorides. Most uranium is transported as U-VI and deposited as U-IV.

3. A) Gen. Cat.--Behavior of actinides in geomedia

B) Yevseyeva, L. S.; Fomina, N. P., 1963, Oxidation-reduction properties of sedimentary uranium bearing rocks: Geochemistry, no. 11, p. 1093-1098.

C) Purpose: examine control of Eh on U-mineralization.

Methods: use of LP-5 potentiometer to measure Eh.

Results: uranium and pyrite contents of the rocks were directly proportional to the change in Eh(ΔEh) in solution. The greatest ΔEh occurred in rocks that contained organic matter. Reduced rocks showed ΔEh ranging from 15 to 30 mv. U content may be small despite a large ΔEh if rock permeability is low.

4 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Bloxam, T. W., 1964, Uranium, thorium, potassium, and carbon in some black shales from the South Wales coalfield: Geochimica et Cosmochimica Acta, v. 28, no. 7, p. 1177-1185.

C) Purpose: obtain data on abundance of U and Th, and their relationship to P and C, in black shales.

Methods: gamma spectrometry, XRD, flame spectrometry, wet chemical analyses.

Results: there is a close, linear relationship between U and organic C. Th/U = 3.2 in these rocks; average U = 4.0 ppm, average Th = 12.3 ppm. Like U and organic C, Th increases linearly with K. Both Th and K have inverse relationships with U.

5 . A) Gen. Cat.--Hydrothermal alteration <u>or</u> Behavior of actinides in geomedia

B) Kovalenko, V. I.; Krinberg, I. A.; Mironov, V. P.; Selivanova, G. I., 1964, Behavior of U, Th, Nb and Ta during albilization of granitoids of the Ognitskii complex (eastern Sayan Mountains): Geochemistry International, v. 1, no. 5, p. 868-874.

C) <u>Purpose</u>: examine behavior of actinides, Na and Tb during metasomatism.

<u>Methods</u>: spectrographic analyses; other methods not discussed.

<u>Results</u>: the contents of all 4 elements increase from the granite to the quartz-albite metasomatic zone. Decreasing alkalinity of the metasomatic facies favors enrichment of U relative to Th and Nb with respect to Ta. U/Th is higher in alaskites with secondary biotite as opposed to secondary metasomatic riebeckite.

6 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Serebryakova, M. B., 1964, Application of physicochemical methods to the determination of the mode of occurrence of uranium in groundwaters: Geochemistry International, v. 1, no. 5, p. 898-907.

C) Purpose: experimentally determine forms of U in waters.

Methods: dialysis, ion exchange, electrodialysis.

Results: colloidal U is absent in the test samples. 95-98% of the uranium occurs as anionic species, specifically, $[UO_2(CO_3)_2(H_2O)_2]^{2-}$, $[UO_2(CO_3)_3]^{4-}$, and UO_2OH^+. All samples had a high carbonate ion content ($CO_3/U > 3$). Cationic UO_2OH^+ accounted for only 2% of the uranium.

7 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Cherdyntsev, V. V.; Kazachevskiy, I. V.; Sulerzhitsky, L. D.; Kuz'mina, Y. A., 1965, Plutonium-239 in nature: Geochemistry International, v. 2, no. 5, p. 918-920.

C) <u>Purpose</u>: assess distribution of ^{239}Pu in nature.

<u>Methods</u>: literature review, alpha spectrometry.

<u>Results</u>: neutron capture by ^{238}U and an unknown heavy element (Z = 84-92.94) are the 2 sources of Pu-239 in nature. ^{239}Pu tends to be enriched in waters relative to U-minerals (^{239}Pu/^{238}U = 10^{-7} in water and 10^{-12} in U ores). ^{239}Pu has been identified in sphene, molybdenite, magnetite, apatite, and zircon in an ore vein, and also in Fe-carbonates and exhaled gases of submarine volcanics.

8 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Dement'yev, V. S.; Syromyatnikov, N. G., 1965, Mode of occurrence of thorium isotopes in groundwaters: Geochemistry International, v. 2, no. 1, p. 141-147.

C) Purpose: gain information on migration of Th in the supergene zone.

Methods: centrifuging, ion exchange, and dialysis.

Results: Th content is highest in waters of low salinity, hardness, pH, and high organic content. Data indicate transport as organic colloidal complexes and anionic complexes involving organic acids. Th-232 is most likely associated with colloids, while Th-230 and Th-228 exist in ionic solution.

9 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Kochenov, A. V.; Zinev'yev, V. V.; Lovaleva, S. A., 1965, Some features of the accumulation of uranium in peat bogs: Geochemistry International, v. 2, no. 1, p. 65-70.

C) Purpose: examine accumulation of U in peat bogs as a possible mechanism of U mineralization.

Methods: wet chemical methods, dialysis.

Results: these U accumulations have formed in an area of normal U concentrations in bedrock and only slightly above background in water. U fixation in peat is a combination of adsorption and reduction of U. These 2 processes result in a stable association between U and organic matter.

10. A) Gen. Cat.--Behavior of actinides in geomedia

B) Yermolayev, N. P.; Zhidikova, A. P.; Zarinskiy, V. A., 1965, Transport of uranium in aqueous solutions in the form of complex silicate ions: Geochemistry International, v. 2, no. 4, p. 629-641.

C) Purpose: establish the behavior of U in silica-rich solutions.

Methods: spectrophotometry, wet chemical methods.

Results: a sub-colloidal U-ion exists in neutral or slightly alkaline waters at less than 200°C. Its formula is $(UO_2OH)(HSiO_3)$, or, equivalently, $[(UO_2OH)(SiO_3)]^-$. The complex is relatively weak and will decompose by precipitation of U and silica gel if pH decreases or concentration of electrolytes increases. Presence of SO_4^{2-} or CO_3^{2-} can result in the formation of U complexes with these anions instead of silica.

11 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Yermolayev, N. P.; Zhidikova, A. P., 1966, Behavior of uranium in progressive metamorphism and ultrametamorphismas observed in the western part of the Aldan Shield: Geochemistry International, v. 3, no. 4, p. 716-731.

C) Purpose: trace the distribution of uranium in rocks undergoing metamorphism.

Methods: petrography, colorimetry.

Results: rocks lose from 20-40% of their U and Th during progressive metamorphism . This is correlated with losses of CO_2 and water. The actinides are converted into mobile forms and may serve as a source for uranium mineralization.

12. A) Gen. Cat.--Behavior of actinides in geomedia

B) Ryzhenko, B. N.; Naumov, G. B.; Goglev, V. S., 1967, Hydrolysis of uranyl ions at elevated temperatures: Geochemistry International, v. 4, no. 2, p. 363-367.

C) Purpose: examine hydrolysis of the uranyl ion at elevated temperatures.

Methods: calculations based on published data.

Results: U concentration is a controlling factor on hydrolysis mechanism, thus experimental data on U behavior at high concentrations cannot be applied to natural systems with low U concentrations. Increase in temperature shifts the boundary between the 2 mechanisms into the higher concentration region. Increase in ionic strength has the opposite effect, but not enough to offset the effect of temperature.

13. A) Gen. Cat.--Behavior of actinides in geomedia

B) Dement'yev, V. S.; Syromyatnikov, N. G., 1969, Conditions of formation of a sorption barrier to the migration of uranium in an oxidizing environment: Geochemistry International, v. 5, no. 2, p. 394-400.

C) *Purpose*: determine the pH interval most favorable to U sorption.

Methods: calculations based on published data.

Results: maximum sorption and minimum solubility of U occur at $pH = 6.0 \pm 0.5$. Below $pH \simeq 5.5$, anionic forms predominate; at $5.5 < pH < 6.5$, cationic forms predominate. Precipitation of insoluble phases may be superimposed on sorption processes.

14. A) Gen. Cat.--Behavior of actinides in geomedia

B) Szalay, S.; Samsoni, Z., 1969, Investigation of the leaching of uranium from crushed magmatic rock: Geochemistry International, v. 6, no. 3, p. 613-623.

C) Purpose: investigate the origin of U in natural waters.

Methods: atomic fluorescence spectroscopy.

Results: equilibrium concentration of U between crushed rock and water is reached within 3-5 hours. Addition of U to this system is taken out of solution by sorption. Granite is the major source of U in water, because it releases U more readily than intermediate or basic rocks.

15. A) Gen. Cat.--Behavior of actinides in geomedia

B) Tugarinov, A. I.; Naumov, V. B., 1969, Thermobaric conditions of formation of hydrothermal uranium deposits: Geochemistry International, v. 7, no. 1, p. 89-103.

C) *Purpose*: calculate temperatures and pressures of formation for minerals of hydrothermal U deposits.

Methods: use of fluid inclusions; methods of analyses unspecified.

Results: U-ores can form in the temperature range 50-350°C. Uraninite or brannerite are formed at temperatures above 250°C; pitchblende is formed at $T \leq 220$°C. Ore formation at pressures higher than lithostatic pressure are the cause of solution movement. Shallower deposits are typically fissure fillings; deeper ones are metasomatic. Metasomatism will also occur at high fluid pressures.

16 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Bertine, K. K.; Chan, L. H.; Turekian, K. K., 1970, Uranium determinations in deep-sea sediments and natural waters using fission tracks: Geochimica et Cosmochimica Acta, v. 34, no. 6, p. 641-648.

C) Purpose: test a rapid method for U determinations.

Methods: fission track analysis using a discharge counter.

Results: comparison of this technique with independent analyses indicate it is an accurate method. U in deep sea sediments varies from 0.5 - 40ppm; in river water it varies from $<$ 0.01 - 1.2 μg U/l. U variation in seawater is not necessarily related to the clay-carbonate ratio.

17 . A) Gen. Cat.--Behavior of actinides in geomedia.

B) Bernat, M.; Bieri, R. H.; Koide, M.; Griffin, J. J.; Goldberg, E. D., 1970, Uranium, thorium, potassium and argon in marine phillipsites: Geochimica et Cosmochimica Acta, v. 34, no. 10, p. 1053-1071.

C) Purpose: study the factors that control the concentrations of U and Th and evaluate the K-Ar method for dating phillipsites.

Methods: alpha spectrometry, XRD, AAS, mass spectrometry.

Results: Th and U decrease, even though phillipsite increases, with depth in the sediment. This can be explained by continuous growth of phillipsite. Varying concentrations of U and Th in phillipsite, clay minerals, and fish teeth indicate competition among these solids for dissolved actinide phases. Without better knowledge of phillipsite formation, K-Ar is not a suitable dating method.

18 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Bonatti, E.; Fisher, D. E.; Joensuu, O.; Rydell, H. S., 1971, Post-depositional mobility of some transition elements, phosphorus, uranium, and thorium in deep sea sediments: Geochimica et Cosmochimica Acta, v. 35, no. 2, p. 189-201.

C) Purpose: establish the mobility of selected elements in early diagenesis.

Methods: AAS, XRD, optical spectroscopy.

Results: reducing conditions (Eh = -400mV) in the deeper sediment are caused by oxidation of organic material. Mn, Ni, Co, P and La are enriched in the oxidized zone; Cr, V, U, and S are enriched in the reduced zone. Fe and Cu are precipitated as sulfides and are immobilized in lower core. Redox reactions account for the distribution of many of these elements, including U. Th is apparently not effected by diagenesis.

19 . A) Gen. Cat.--Behavior of actinides in geomedia <u>or</u> Alteration studies

B) Capaldi, G.; Civetta, L.; Gasparini, P., 1971, Fractionation of the ^{238}U decay series in the zeolitization of volcanic ashes: Geochimica et Cosmochimica Acta, v. 35, no. 10, p. 1067-1072.

C) Purpose: report behavior of U and Th and fractionation of ^{238}U decay series during the alteration of a Holocene ash fall.

Methods: alpha and gamma spectrometry.

Results: Ra, Th , and U concentrations decrease with increasing zeolitization of the rock. Equilibrium prevails for ^{232}Th series in all types of ash. Excess ^{238}U over ^{230}Th is present in all cases. Zeolitization enhances disequilibrium among decay series members.

20. A) Gen. Cat.--Behavior of actinides in geomedia

B) Dall'Aglio, M., 1971, A study of the circulation of uranium in the supergene environment in the Italian Alpine Range: Geochimica et Cosmochimica Acta, v. 35, no. 1, p. 47-59.

C) Purpose: report anomalies discovery while prospecting for U.

Methods: wet chemical techniques.

Results: U may be enriched in water or sediments simply because it is so easily leached and brought into solution. Some U in natural waters is precipitated by organic matter, resulting in high U concentrations in alluvium.

21. A) Gen. Cat.--Behavior of actinides in geomedia

B) Kovalev, V. P.; Malyasova, Z. V., 1971, The content of mobile uranium in extrusive and intrusive rocks of the eastern margin of the South Minusinsk basin: Geochemistry International, v. 8, no. 4, p. 541-549.

C) Purpose: examine contents and mobility of U in igneous rocks.

Methods: microradiography, XRD, other methods not elaborated on.

Results: extrusive rocks yield practically no U during leaching. U can be leached from intrusive rocks until they are converted to glass. Retention of U by lavas is due to fine dispersion of U to begin with and formation of a silica gel layer which prevents diffusion. This layer can be destroyed only at high temperatures.

22. A) Gen. Cat.--Behavior of actinides in geomedia.

B) Yermoloyev, N. P., 1971, Processes of redistribution and extraction of uranium in progressive metamorphism: Geochemistry International, v. 8, no.4, p. 599-609.

C) Purpose: consider likely mechanisms of U redistribution during metamorphism from the viewpoint of physical chemistry.

Methods: calculations based on published data.

Results: loss of U increases as metamorphism progresses. Data indicate 3 mechanisms of U removal: 1) recrystallization, accompanied by loss of U and other trace elements into solution; 2) desorption from mineral surfaces; 3) dissolution of U-carrier minerals in ultrametamorphism (remelting). Fe, Ti, Zn, and REE minerals will take up U during recrystallization. Distribution of U can allow reconstruction of the path of metamorphism.

23. A) Gen. Cat.--Behavior of actinides in geomedia

B) Petrov, B. V.; Krendelev, F. P.; Bobrov, V. A.; Tsimbalist, V. G., 1972, Behavior of radioelements and gold during metamorphism of sedimentary rocks in the Patom Uplands: Geochemistry International, v. 9, no. 4, p. 647-655.

C) Purpose: examine element migration during metamorphism in order to reveal sources and methods of formation of ores.

Methods: petrography, gamma spectrometry, flame photometry, and other methods unspecified.

Results: Au accumulates in epidote-amphibolite or high-T greenschist facies, but migrates out of amphibolite facies. Radioelements U, Th, and K are immobile during this type of metamorphism. Maximum U content can be expected in zones of minimal metamorphism. There is no correlation between Au and the radioelements.

24 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Rackley, R. I., 1972, Environment of Wyoming Tertiary uranium deposits: American Association of Petroleum Geologists Bulletin, v. 56, no. 4, p. 755-774.

C) Purpose: describe formation of Wyoming Tertiary U deposits.

Methods: analysis of map and well data.

Results: the single most important event in the accumulation of a sandstone -type ore body is sedimentation in a suitable environment. Application of the geochemical cell concept can be very helpful in U mining. Favorability of an ore body can be determined using:

$$\text{favorability} = t \cdot R/r$$

where t = thickness of cell or zone host sandstone unit

R = radioactivity on an arbitrary scale from 1-10 (1=background)

r = thickness of cell / thickness of host sandstone unit

r always will be ≤ 1 and usually $\geq .4$

25 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Sergeyeva, E. I.; Nikitin, A. A.; Khodokoskiy, I. L.; Naumov, G. B., 1972, Experimental investigation of equilibria in the system UO_3-CO_2-H_2O in 25-200°C temperature interval: Geochemistry International, v. 9, no. 6, p. 900-910.

C) Purpose: determine thermodynamic properties of uranyl carbonate complexes.

Methods: colorimetry, flame photometry, X-ray analysis.

Results: for the formation of UO_2CO_3, $\underline{H}^o_{298.15} = -405.7 \pm 1.8$ kcal/mol; $\underline{S}^o_{298.15} = 33.9 \pm 7.0$ kcal/mol · deg. Calculation of stability diagrams indicate a large field of undissociated uranyl carbonate in solution in neutral and weakly acid solutions. Crystallization of UO_2CO_3 (rutherfordite) requires a high concentration of U and oxidizing conditions.

26. A) Gen. Cat.--Behavior of actinides in geomedia

B) Cheney, E. S.; Trommell, J. W., 1973, Isotopic evidence for inorganic precipitation of uranium roll ore bodies: American Association of Petroleum Geologists Bulletin, v. 57, no. 7, p. 1297-1304.

C) Purpose: to amplify suggestions that S and C isotopic data already in the literature can be reinterpreted as evidence for the inorganic hypothesis.

Methods: the authors have analyzed previously published data.

Results: bacterial activity is necessary in the formation of roll ore bodies because pyrite or other sulfides must be present in host rock to initiate mineralization. However, bacterial activity is absent at the ore forming stage.

27. A) Gen. Cat.--Behavior of actinides in geomedia or Sorption studies

B) Gavshin, V. M.; Bobrov, V. A.; Pyalling, A. O.; Reznikov, N. V., 1973, The two types of uranium accumulation in rocks by sorption: Geochemistry International, v. 10, no. 3, p. 682-690.

C) Purpose: examine sorptive capabilities of 2 substances with respect to U.

Methods: petrography, alpha radiography, ordinary fluorescence, wet chemical methods.

Results: phosphates contain U and U decay products in their structure and show only slight deviations from equilibrium between U and Ra. No U-minerals occur in phosphatic rocks. Rocks bearing uraniferous hydromicas allow the formation of U-minerals because U is only held on to the surfaces of these aluminosilicates. Under oxidizing conditions, urano complexes form; under reducing conditions, primary uranium minerals form.

28 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Haji-Vassilou, A.; Kerr, P. F., 1973, Analytic data on nature of urano-organic deposits: American Association of Petroleum Geologists Bulletin, v. 57, no. 7, p. 1291-1296.

C) Purpose: compare analytic data on urano-organic material with similar data on coal and petroleum.

Methods: XRD, XRF, infrared spectroscopy, organic element analysis.

Results: organic matter in major urano-organic ores is genetically related to decay of vegetation or coal. Organic matter can reduce U^{6+}, without aid of H_2S. Low rock coals are especially effective in extracting U from U-bearing solutions.

29 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Mo, T.; Suttle, A. D.; Sackett, W. M., 1973, Uranium concentrations in marine sediments: Geochimica et Cosmochimica Acta, v. 37, no.1, p. 35-51.

C) Purpose: study marine chemistry and cycling of uranium.

Methods: delayed neutron counting.

Results: amount of U in sediments correlated directly with organic carbon in anoxic environments. Both Ca and U decrease as a function of depth in marine Mn nodules. Deep water carbonates also have relatively high U concentrations. Observed variations can be accounted for by U enrichment in anoxic nearshore environments followed by redeposition in deep ocean.

30 . A) Gen. Cat.--Behavior of actinides in geomedia or Hydrothermal systems

B) Rydell, H. S.; Bonatti, E., 1973, Uranium in submarine metalliferous deposits: Geochimica et Cosmochimica Acta, v. 37, no. 12, p. 2557-2565.

C) Purpose: define the source and manner of enrichment of U in submarine metalliferous deposits.

Methods: alpha spectrometry.

Results: these hydrothermal deposits contain about 10ppm U. $^{234}U/^{238}U$ is generally equivalent to that of seawater, although in some cases it is anomalously high, usually accompanied by low total U. This might be caused by a loss of U from seawater into basalt. High $^{234}U/^{238}U$ could result from leaching of U from basalt later.

31. A) Gen. Cat.--Behavior of actinides in geomedia

B) Childers, M. O., 1974, Uranium occurrences in Upper Cretaceous and Tertiary strata of Wyoming and northern Colorado: Mountain Geologist, v. 11, no. 4, p. 131-147.

C) Purpose: describe ore-forming processes at uranium occurrences in Wyoming and Colorado.

Methods: use of drill hole data, field studies.

Results: the prevailing savannah climate in Eocene and Oligocene time was a major control on U mineralization. U was soluble in oxidizing surface and groundwaters, and was precipitated when groundwater met the reduced large-stream facies or when surface water stagnated in swamps. Probable source for U was the granite bedrock.

32 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Langen, R. E.; Kidwell, A. L., 1974, Geology and geochemistry of the Highland uranium deposit, Converse County, Wyoming: Mountain Geologist, v. 11, no. 2, p. 85-93.

C) Purpose: describe the Highland deposit.

Methods: petrography, XRF, field studies

Results: sources of U for this deposit were: 1) Precambrian basement rock, and; 2) Oligocene volcanic tuffs. Leaching and transport was accomplished by slightly alkaline, oxidizing solutions of the bicarbonate or bicarbonate-sulfate type; U was complexed as a uranyl carbonate. Reduction immobilized the U as uraninite. H_2S, formed by anaerobic bacteria, was the principal reductant.

33 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Osmond, J. K.; Kaufman, M. I.; Cowart, J. B., 1974, Mixing volume calculations, sources and aging trends of Floridan aquifer water by uranium isotopic methods: Geochimica et Cosmochimica Acta, v. 38, no. 7, p. 1083-1100.

C) Purpose: present a method of calculating mixing data and defining groundwater patterns using $^{234}U/^{238}U$.

Methods: alpha spectrometry.

Results: plotting $^{234}U/^{238}U$ against the reciprocal of U concentration permits the grouping of isotopically related waters in a hydrologically meaningful way. This type of study could be used in conjunction with flow net analysis. Preliminary data from a Florida aquifer indicates an increasing $^{234}U/^{238}U$ in the direction of hydraulic gradient, possibly a result of alpha recoil input of ^{234}U.

34. A) Gen. Cat.--Behavior of actinides in geomedia or Hydrothermal alteration

B) Plyushchev, Y. V.; Ryabova, L. A., 1974, Accumulation levels of U and Th in hydrothermal minerals: Geochemistry International, v. 11, no. 4, p. 820-830.

C) Purpose: characterize U and Th contents in nonradioactive minerals from mineralized zones.

Methods: XRF, colorimetry.

Results: during greisen formation, U is concentrated in minerals to a greater extent as the process continues; maximum U is found in the final product, the ore minerals. Th shows a slightly reversed trend, relative to U, with a strong affinity for fluorite. There is little differentiation or concentration in solid phases of Th and U during secondary quartzite or gold-bearing beresite formation. Maximum differentiation occurs in Mo-bearing beresites as Th is concentrated in mineral phases early and U later.

35 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Zverev, V. L.; Spiridonov, A. I., 1974, Uranium isotopes in Central Asia natural waters: Geochemistry International, v. 11, no. 4, p. 871-873.

C) Purpose: evaluate effect of precipitation on U budgets in natural waters.

Methods: none discussed.

Results: sources of U in precipitation have been identified as continental aerosols from nearby arid areas and marine salt aerosols. Thus, climate is a major factor in determining the U isotope balance of surface waters, in this case accounting for low U isotope ratios in rivers.

36. A) Gen. Cat.--Behavior of actinides in geomedia

B) Eargle, D. H.; Dickinson, K. A., Davis, B. O., 1975, South Texas uranium deposits: American Association of Petroleum Geologists Bulletin, v. 59, no. 5, p. 766-779.

C) Purpose: to characterize the South Texas U deposits

Methods: drilling and airborne-radioactivity survey data, geochemical surveys of soil, air, and water.

Results: ore was formed by leaching of Miocene tuffs, closely following deposition, by oxidizing alkaline groundwaters and carried through permeable sandstone to subsurface where U was precipitated in roll fronts as it met reducing conditions caused by H_2S or CH_4. Host rock is tuffaceous, arkosic sandstone enclosed in tuff, zeolitic mudstone, clay and lignite beds. Near surface deposits have been extensively oxidized and are generally out of radioactive equilibrium.

37 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Thompson, P.; Ford, D. C.; Schwarcz, H. P., 1975, $^{234}U/^{238}U$ ratios in limestone cave seepage waters and speleothem from West Virginia: Geochimica et Cosmochimica Acta, v. 39, no. 5, p. 661-669.

C) Purpose: assess the $^{234}U/^{238}U$ dating method.

Methods: alpha-spectrometry.

Results: speleothem, ranging in age from 2000 to 200,000 years BP, contain U with $^{234}U/^{238}U$ ratios greater than 1. This ratio varies significantly from month to month in waters at given test site, and their values differ from the speleothem they are depositing. This is attributed to either: 1) long term averaging out of fluctuations, or, 2) fractionation of U during precipitation on to the speleothem.

38 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Pavshukov, V. V.; Komlev, L. V.; Anderson, Y. B.; Smyslova, I. G., 1975, X-ray microprobe data on the state of the U-Pb system in uranium ores: Geochemistry International, v. 12, no. 5, p. 251-261.

C) Purpose: examine the state of U-Pb systematics to improve accuracy of dating techniques.

Methods: X-ray microanalyzer.

Results: uraninite retains most radiogenic Pb, while coffinite and braunerite tend to diffuse Pb out, regardless of the geochemical setting. Radiogenic Pb that escapes from U-minerals is sorbed by sulfide minerals. Pb can be lost from uranite during alteration; hydration tends to liberate U instead of Pb.

39 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Joshi, L. U.; Ganguly, A. K., 1976, Anomalous behavior of uranium isotopes in coastal marine environment of the west coast of India: Geochimica et Cosmochimica Acta, v. 40, no. 12, p. 1491-1496.

C) Purpose: examine U activities and isotopic ratios in coastal sediments.

Methods: alpha counting with silicon surface barrier detector.

Results: $^{234}U/^{238}U = 1.12-1.14$; $^{235}U/^{238}U = 0.046$, which is the same as for other natural U. Disequilibrium between U-234 and U-238 exists only on the surface of sediment particles. Removal of organic matter yields equilibrium values. This is compatible with data on thorium isotopes.

40 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Serebrennikov, V. S.; Maksimova, I. G., 1976, The deposition mechanism of uranium from mineral waters containing CO_2: Geochemistry International, v. 13, no. 5, p. 167-174.

C) Purpose: examine the role of CO_2 in the deposition of U.

Methods: fission-fragment radiography.

Results: there is a positive correlation between U concentrations in travertine and in the source water; $K_D \simeq 1000$. U is coprecipitated with carbonates and sorbed by them, resulting in a uniform distribution throughout the travertine. Sorption is due to an excess of cations on carbonate surface layers; U exists as the anion uranyl carbonate and is thus readily sorbed.

41 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Titayeva, N. A.; Veksler, T. I., 1977, The state of radioactive equilibrium in the uranium and thorium series as an indicator of migration of radioactive elements and active interaction between phases under natural condition: Geochemistry International, v. 14, no. 4, p. 99-107.

C) Purpose: analyze the geochemical behavior of U, Th, and Ra.

Methods: luminescence, colorimetry, emanation, alpha spectrometry.

Results: radioactive disequilibrium is the rule rather than the exception. Disequilibrium can serve as an indicator of direction of migration of radioelements (from liquid to solid via sorption, or solid to liquid via desorption and solution). The zone of active water exchange in granite massifs favors migration of U, Ra, as well as Th.

42 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Titayeva, N. A.; Taskayeva, A. I.; Ovchenko, V. Y.; Aleksakhin, R. M.; Shuktomova, I. I., 1977, U, Th, and Ra isotope compositions in soils in prolonged contact with radioactive stratal waters: Geochemistry International, v. 14, no. 5, p. 57-63.

C) Purpose: examine effects of radioelement contaminated waters on soils.

Methods: alpha spectrometry.

Results: Ra, and to a lesser extent Th, are firmly sorbed in humus horizons that have reacted with CaCl brines. Ra is more mobile than Th in peaty soils. The stratal waters are continuously being enriched in Ra and Th; the source of the enrichment is the aquifer rock. In general, there is disequilibrium between parents and daughters for all series.

43 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Burnett, W. C.; Veeh, H. H., 1977, Uranium-series disequilibrium studies in phosphorite nodules from the west coast of South America: Geochimica et Cosmochimica Acta, v. 41, no. 6, p. 755-764.

C) Purpose: use U-series to obtain clues about mode of formation of P-nodules.

Methods: surface barrier detection, alpha spectrometry, fission track mapping techniques, SEM.

Results: U is associated with apatite. Fractionation due to redox differences is minor. Data indicate that phosphorites are currently forming and that interglacial periods are more favorable to apatite genesis than glacial periods.

44 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Al-Shaieb, Z; Olmstead, R. W.; Shelton, J. W.; May, R. T.; Owens, R. T.; Hanson, R. E., 1977, Uranium potential of Permian and Pennsylvanian sandstones in Oklahoma: American Association of Petroleum Geologists Bulletin, v. 61, no. 3, p. 360-375.

C) Purpose: to relate U deposits and anomalies in Permian and Pennsylvanian sandstones to geologic parameters.

Methods: gamma-ray logs and cores, geologic mapping, petrography.

Results: U and radioactive anomalies in Permian and Pennsylvanian sandstone in Oklahoma are related to one or more of the following: 1) relatively high f_{sp} content, 2) hydrocarbon seepage or production, 3) organic matter, 4) evaporitic depositional conditions.

45. A)Gen. Cat.--Behavior of actinides in geomedia

B) Langford, F. F., 1977, Surficial origin of North American pitchblende and related uranium deposits: American Association of Petroleum Geologists Bulletin, v. 61, no. 1, p. 18-42.

C) Purpose: explain the association of U-ore with terrestrial sediments.

Methods: a literature review.

Results: 3 major changes occurred in ore concentration in North America with time: 1) Detrital U deposits formed during Aphebian time due to mechanical weathering of granitic rocks; these are older than 1.8 billion years; 2) From 1.8 billion years ago until Devonian time, U was mobile due to oxygenic atmosphere and precipitated as pitchblende veins in fractures under reducing conditions; 3) Abundance of land plants from Devonian on produced tabular U deposits as this organic matter became buried in terrestrial sediments, forming local reducing areas.

Hydrothermal formation seems infrequent as such a large percentage are formed in terrestrial sediments.

46. A) Gen. Cat.--Behavior of actinides in geomedia

B) Kochenov, A. V.; Korolev, K. G.; Dubinchuk, V. T.; Medvedev, Y. L., 1977, Experimental data on the conditions of precipitation of uranium from aqueous solutions: Geochemistry International, v. 14, no. 6, p. 82-87.

C) Purpose: obtain information on mechanisms of U accumulation.

Methods: SEM, XRD.

Results: precipitation of U on a reduction barrier always involves sorption on phase boundaries. Sorption and redox reactions are combined as the characteristic mechanism of near surface concentration of U. The most complete extraction of U from waters occurs when sediments are strongly enriched in organic matter and H_2S.

47 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Dubinchuk, V. T.; Pen'kov, V. F.; Uspenskiy, V. A.; Avdonin, A. S.; Shevchenko, V. N., 1977, Replacement of uraninite by kerite and coffinite: Geochemistry International, v. 14, no. 1, p. 182-187.

C) Purpose: determine mechanisms whereby kerite replaces uraninite.

Methods: XRD, TEM.

Results: radiation induced chemical changes are responsible for replacement of uraninite by kerite and coffinite. Alpha-radiation causes changes in bitumen structure near uraninite grains, causing instability in the bitumen. Eventually, the uraninite is destroyed and the U is distributed throughout the bitumen, together with coffinite.

48 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Dubinchik, V. T.; Sidorenko, G. A., 1978, On the occurrence of lead in natural uranium oxides: Geochemistry International, v. 15, no. 1, p. 61-65.

C) Purpose: examine occurrence of radiogenic lead in U-oxides.

Methods: electron microscopy, microdiffraction.

Results: the degree of oxidation of the U-oxide controls the mode of occurrence of Pb. If U is "self-oxidized", no reaction occurs between U and Pb, and U^{6+} is not removed. Pb exists as metallic lead. Oxidation by outside sources can disperse Pb and U and result in precipitation of $PbU^{6+}O_4$ (lead uranate).

49. A) Gen. Cat.--Uranium minerals

B) Gramaccioli, C. M.; Segalstad, T. V., 1978, A uranium- and thorium-rich monazite from a south-alpine pegmatite at Piona, Italy: American Mineralogist, v. 63, no. 7 and 8, p. 757-761.

C) Purpose: to conduct a detailed investigation of this U- and Th-rich monazite.

Methods: XRD, petrography, absorption spectrum studies, electron microprobe.

Results: electron microprobe analyses indicate a high content of uranium (16% UO_2) and a moderately high content of thorium (11% ThO_2). A relevant quantity of CaO (4.4%) is also present, and silica is nearly absent (.16%). The mineral might be considered as a uranium-rich cheralite, or as its uranium-bearing equivalent; the name monazite is used on account of the ration (Ca + U + Th)/ Ce + La + Pr + Nd) which is below unity (.91 against 1.47 for type cheralite).

50. A) Gen. Cat.--Behavior of actinides in geomedia

B) Huang, W. H., 1978, Geochemical and sedimentologic problems of uranium deposits of Texas Gulf Coastal Plain: American Association of Petroleum Geologists Bulletin, v. 62, no. 6, p. 1049-1062.

C) Purpose: document the data available on existing U deposits in south Texas and identify problems in understanding type II U deposits.

Methods: literature review.

Results: the author identifies 3 general groups of factors that interact dynamically to control mobility and accumulation of U:

1) Physical: viscosity of host fluid, permeability of host rock, potential and temperature differences;
2) Chemical - mineralogic: ionic strength of solution, activities of species in solution, and pore water, solubility of ore and gangue minerals, surface activity and energy of minerals in host rocks, Eh, pH;
3) Hydrologic: fluctuation of redox front.

The author also notes the possible importance of adsorption and precipitation of U.

51 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Langmuir, D., 1978, Uranium solution - mineral equilibria at low temperatures with applications to sedimentary ore deposits: Geochimica et Cosmochimica Acta, v. 42, no. 6, p. 547-569.

C) Purpose: update and discuss the low-T solution/mineral equilibria of uranium.

Methods: calculations based on published data.

Results: U in natural waters is normally complexed. In anoxic waters, U^{4+} fluorides are important at $pH \leq 3$. At intermediate Eh's, UO_2^{+} predominates if $pH \leq 7$; at higher pHs , uranyl phosphates or carbonates can form if P or C is present. In oxidized waters, UO_2^{2+} fluorides or uranyl ion predominate at $pH < 5$; at $pH = 4-7.5$, $UO_2(HPO_4)_2^{2-}$ is most important, and at higher pHs, UO_2-carbonates form. At 25°C, UO_2, αU_3O_8, and schoepite are the stable U oxides and hydroxides. Coffinite can form if $SiO_2 > 60$ppm. Some uranyl minerals have solubilities as low as .2 ppb U. Sorption of uranyl is at a maximum in the pH range 5-8.5.

52 . A) Gen. Cat.--Uraniferous materials

B) Levinson, A. A.; Bland, C. J., 1978, Examples of the variability of disequilibrium and the emanation factor in some uraniferous materials: Canadian Journal of Earth Sciences, v. 15, no. 11, p. 1867-1871.

C) Purpose: to determine the U_3O_8 and eU_3O_8 contents and activities of ^{226}Ra and ^{214}Bi from uranium localities in Thailand and southern Africa, and see if this is a possible exploration guide.

Methods: chemical analyses (fluorimetry, alpha spectrometry)

Results: The emanation factor, E, is strongest among granites and conglomerates, and weakest around basic and calcareous rocks. Accessory minerals, even though high in uranium, show low radon emanations (generally less than 2%).

53 . Gen. Cat.--Behavior of actinides in geomedia

B) Means, J. L.; Crerar, D. A.; Borcsik, M. P.; Duguid, J. O., 1978, Adsorption of Co and selected actinides by Mn and Fe oxides in soils and sediments: Geochimica et Cosmochimica Acta, v. 42, no.12, p. 1763-1773.

C) Purpose: show that actinides are retained by Mn and Fe oxides in soils.

Methods: AAS, gamma and alpha counting, XRD, wet chemical techniques.

Results: ^{60}Co and actinides, predominantly ^{244}Cm, ^{241}Am, and ^{238}Pu, are sorbed preferentially by Mn-oxides relative to Fe-oxides. This is probably due to the unique surface and colloidal properties of Mn oxides.

54 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Chalov, P. I.; Tuzova, T. V.; Tikhonov, A. I.; Merkulova, K. I.; Svetlichnaya, N. A., 1979, Nonequilibrium uranium as an indicator in the study of groundwater origin and circulation: Geochemistry International, v. 16, no. 5, p. 124-131.

C) Purpose: use $^{234}U/^{238}U$ to construct a scheme for the formation and circulation of groundwater in a particular deposit.

Methods: alpha spectrometry.

Results: 2 groundwater regions are areas of mixing according to $^{234}U/^{238}U$; each source and its contribution can be determined. This ratio can be used to differentiate streams and construct underground circulation patterns.

55 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Dubinchuk, V. T.; Sidorenko, G. A., 1979, The position of U(VI) in natural oxides: Geochemistry International, v.16, no. 6, p. 145-151.

C) Purpose: detect structural changes in uraninite during oxidation of U.

Methods: XRD, SEM, microdiffractor, microprobe.

Results: U is lost from uraninite upon oxidation resulting in a decreased unit cell parameter. U^{6+} is segregated on (h00) and (hk0) planes, eventually resulting in U-hydroxides. The reduction in unit cell size can be used to determine the degree of oxidation of U.

56 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Dymkov, Y. M.; Pavlov, Y. G.; Zav'yalov, Y. N., 1979, Phase composition and morphogenetic features of uraninite from the Oklo reactor, Gabon: Geochemistry International, v. 16, no. 1, p. 113-124.

C) Purpose: describe the formational history of uraninite at Oklo.

Methods: XRD, electron microscope.

Results: U-ore was deposited in several stages, showing signs of primary spherulitic growth, various pseudomorphs, and later recrystallization. Original composition and lattice have not been preserved. There are at least 3 U-oxides with different lattice parameters, compositions, and times of formation in the ore. Some U-oxides were formed by secondary hydrothermal redistribution.

57 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Kozlova, P. S.; Gurvich, M. Y., 1979, The behavior of uranium in post-magmatic alteration of potassic alkali rocks: Geochemistry International, v. 16, no. 4, p. 109-119.

C) Purpose: consider behavior of radioelements in post magmatic alteration.

Methods: fission track radiography

Results: early high-temperature soda metasomatism involved influx of Th, Ce-group rare earths and minor U and Ni. Alteration at medium to low temperatures results in considerable loss of U, Pb, Zn, Y, La, and Ce. In the supergene zone, U is sorbed onto Fe-hydroxides and leucoxene.

58. A) Gen. Cat.--Behavior of actinides in geomedia

B) Rafal'skiy, R. P.; Alekseyev, V. A.; Anan'yeva, L. A., 1979, Phase compositions of natural and synthetic uranium oxides: Geochemistry International, v. 16, no. 6, p. 13-26.

C) Purpose: determine relative proportions of U and O in natural and synthetic phases.

Methods: wet chemical anayses, XRD.

Results: below 350°C, UO_{2+x} $(0 < x < .38)$ exists, but is metastable, along with U_3O_8(orthorhombic) to yield O/U = 2.38-2.60. O/U in natural uraninites does not exceed 2.38. Oxidation of U^{4+} leads to the formation of an x-ray amorphous U-oxide. Data indicate that natural U-oxides containing U^{4+} are metastable.

59. A) Gen. Cat.--Behavior of actinides in geomedia

B) Sharborne, J. E., Jr.; Buckavic, W. A.; Dewitt, D. B.; Hellinger, T. S.; Pavlak, S. J.; 1979, Major uranium discovery in volcaniclastic sediments. Basin and Range Province, Yavapai County, AZ: American Association of Petroleum Geologists Bulletin, v. 63, no. 4, p. 621-646.

C) Purpose: describe properties and genesis of the Anderson Mine U deposit.

Methods: surface and subsurface mapping (using drill hole data, unspecified), autoradiography, XRD, microprobe and petrographic analyses, quantitative geochemical analyses (unspecified).

Results: compaction and dewatering of uraniferous volcanic-rich lake sediments led to the migration of U-carbonate-silicate formational waters upward or outward from basin (i.e., diagenetic). Local reducing conditions cause precipitation of U and other base metals. The reductant was H_2S generated by decaying organic matter. Major U source was volcanic rocks. A marked increase in Li, V_2O_5, U_3O_8 and possibly F surrounding the deposit may be indicative of a regional chemical zonation.

60 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Dongarra, G.; Langmuir, D., 1980, The stability of UO_2OH^+ and $UO_2[HPO_4]_2^{2-}$ complexes at 25°C: Geochimica et Cosmochimica Acta, v. 44, no. 11, p. 1747-1751.

C) Purpose: remeasure the cumulative association constant (β_2) for uranyl-phosphate.

Methods: potentiometric titration.

Results: $\log \beta_2 = 18.3 \pm 0.2$ at 25°C

Association constant for $UO_2OH^+ = 8.9 \pm 0.1$ (also at 25°C).

61. A) Gen. Cat.--Movement of actinides in geomedia

B) Ellis, G. K., 1980, Distribution and genesis of sedimentary uranium near Curnamona, Lake Frome Region, South Australia: American Association of Petroleum Geologists Bulletin, v. 64, no. 10, p. 1643-1657.

C) Purpose: discuss distribution and genesis of U mineralization in Billeroo channel.

Methods: resistivity and gravity surveys, open hole drilling, γray logging (calibrated against DOE test pits at Casper, WY).

Results: host sands are early Tertiary and deposited in braided stream environment. Preliminary information indicates that in situ leaching would be very effective for extraction of ore (ore is 1,800 metric tons eU_3O_8, grade is .11%). Ore is concentrated on interfaces between channels and longitudinal bars. Permeability differences have led to formation of geochemical cells in each sand. Most mineralization is assoc. with the lateral redox interface of each cell; the terminal interface is represented by a series of narrow oxidized fingers reaching downstream from main oxidized area. Mineralization was contemporaneous with deposition; remobilized afterward. Concentration was completed by dissolution and reprecipitation ahead of oxidizing cells.

62 . A) Gen. Cat.--Uranium minerals

B) Himmelberg, G. R.; Miller, T. P., 1980, Uranium- and thorium-rich vesuvianite from the Seward Peninsula, Alaska: American Mineralogist, v. 65, no. 9 and 10, p. 1020-1025.

C) Purpose: to report a recent finding of a U- and Th-rich metamict vesuvianite in syenite and nepheline syenite.

Methods: petrography, chemical analyses (delayed neutron activation, gamma-ray spectrometric analysis, XRD.

Results: results suggest that the vesuvianite and its host rocks of syenite and nepheline syenite were formed by metasomatic activity involving the introduction of alkali elements, U, Th , Zr, and REE into the syenite and monzonite of the Kachauik pluton.

63. A) Gen. Cat.--Behavior of actinides in geomedia

B) Hussain, N.; Krishnaswami, S., 1980, U-238 series radioactive disequilibrium in groundwaters: implications to the origin of excess U-234 and fate of reactive pollutants: Geochimica et Cosmochimica Acta, v. 44, no. 9, p. 1287-1291.

C) Purpose: understand the behavior of reactive elements in groundwaters.

Methods: chemical techniques, Geiger counter.

Results: abundances of ^{234}Th and ^{210}Pb are grossly deficient relative to their parents, ^{238}U and ^{222}Rn, respectively. This can be accounted for by the adsorption of the daughters. Residence times for these daughters is about one day,so irreversible removal of them from groundwater can occur on very short time scales. This fast removal indicates that excess ^{234}U originates as leachate from soil grains.

64. A) Gen. Cat.--Behavior of actinides in geomedia

B) Langmuir, D.; Herman, J. S., 1980, The mobility of thorium in natural waters at low temperatures: Geochimica et Cosmochimica Acta, v. 44, no. 11, p. 1753-1766.

C) Purpose: evaluate the distribution of aqueous thorium species and the solubility of thorianite at various ligand concentrations.

Methods: calculations based on published data.

Results: dissolved thorium is virtually always complexed in natural waters.

Dominant species:

$pH < 4.5$ - $Th(SO_4)_2^{o}$, ThF_2^{2+}, $Th(HPO_4)_2^{o}$
$4.5 < pH < 7.5$ - $Th(HPO_4)_3^{2-}$
$pH > 7.5$ - $Th(OH)_4^{o}$

Stability constants indicate that, in organic rich water, organic complexes predominate over inorganic complexes. The tendency for thorium to complex probably greatly enhances its solubility, but slow solution rate of thorium minerals and sorption processes probably limit maximum thorium concentrations in natural H_2O.

65 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Moreira-Nordeman, L. M.; 1980, Use of $^{234}U/^{238}U$ disequilibrium in measuring chemical weathering rate of rocks: Geochimica et Cosmochimica Acta, v. 44, no. 1, p. 103-108.

C) Purpose: define weathering rates, using radioactive tracers, in the preto River Basin, Brazil.

Methods: alpha-ray spectroscopy.

Results: uranium radioactivity can be used to calculate a coefficient of partial solution for an area, allowing a weathering rate to be calculated. This method yields a rate of 0.04 mm/year (vertical erosion) for the Preto River Basin.

66. A) Gen. Cat.--Behavior of actinides in geomedia

B) Serebrennikov, V. S.; Dorofayeva, V. A., 1980, Forms of uranium in the production solutions from areas of underground leaching of epigenetic uranium deposits: Geochemistry International, v. 17, no. 5, p. 67-71.

C) Purpose: determine forms of 4 in solution under various Eh and pH conditions.

Methods: calculations based on published data

Results: at pH's above 6.0, U is in the form of uranyl carbonate complexes; at pH's $<$ 6.0, uranyl sulfates predominate.

67. A) Gen. Cat.--Behavior of actinides in geomedia

B) Thein, M.; Ballestra, S.; Yamato, A.; Fukai, R., 1980, Delivery of transuranic elements by rain to the Mediterranean Sea: Geochimica et Cosmochimica Acta, v. 44, no. 8, p. 1091-1097.

C) Purpose: obtain delivery data for radionuclides.

Methods: analysis of rainwater using chemical techniques, alpha spectrometry, beta counting, silicon surface barrier detector.

Results: annual delivery rates (in pCim^{-2}):

$^{238}\mathrm{Pu} = 0.18 \pm 0.01$

$239 + {}^{240}\mathrm{Pu} = 8.1 \pm 0.1$

$^{241}\mathrm{Am} = 0.58 \pm 0.02$

$^{137}\mathrm{Cs} = 351 \pm 4$

Annual activity ratios:

$^{238}\mathrm{Pu} \,/\, 239 + {}^{240}\mathrm{Pu} = 0.022$

$^{241}\mathrm{Am} \,/\, 239 + {}^{240}\mathrm{Pu} = 0.072$

$239 + {}^{240}\mathrm{Pu} \,/\, {}^{137}\mathrm{Cs} = 0.023$

Data indicates that upper limits for mean residence times are 12.3 years for $239 + {}^{240}\mathrm{Pu}$ and 2.9 years for $^{241}\mathrm{Am}$.

68 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Airey, P. L.; Roman, D., 1981, Uranium series disequilibria in the sedimentary uranium deposit at Yeelirrie, Western Australia: Australian Journal of Earth Sciences, v. 28, no. 3, p. 357-363.

C) Purpose: examine causes of U-series disequilibria at Yeelirrie.

Methods: alpha spectrometry.

Results: mean values of $^{234}U/^{238}U$ and $^{230}Th/^{234}U$ are 1.38 ± 0.10 and 0.83 ± 0.28, respectively. The large variability in $^{230}Th/^{234}U$ is evidence of translocation of U subsequent to deposition. Daughter product separation is due to varying mobilities of Th and U.

69. A) Gen. Cat.--Behavior of actinides in geomedia

B) Alberts, J. J.; Orlandini, K. A., 1981, Laboratory and field studies of the relative mobility of ^{239,240}Pu and ^{241}Am from lake sediments under oxic and anoxic conditions: Geochimica et Cosmochimica Acta, v. 45, no. 10, p. 1931-1939.

C) Purpose: investigate mobility of Pu and Am, with respect to Fe and Mn, in natural sediments, and determine the effects of reducing conditions and organic material.

Methods: AAS, chemical analyses.

Results: under anaerobic conditions, ^{241}Am is more easily extracted from lake sediments than is ^{239,240}Pu. Extractibility of these actinides is not appreciably different in anaerobic or aerobic conditions. There is no evidence of recycling of these species from sediment; adsorption does not appear related to extractability of Fe or Mn or presence of organic compounds.

70 . A) Gen. Cat.--Uranium deposits, granite

B) Burwash, R. A.; Cape, D. F., 1981, Petrology of the Fort Smith-Great Slave Lake radiometric high near Pilot Lake, N.W.T.: Canadian Journal of Earth Science, v. 18, no. 5, p. 842-851.

C) Purpose: to do a detailed petrographic-geochemical study of the Pilot Lake area.

Methods: petrography, chemical analysis (XRF, delayed NAA).

Results: anomalously high radioactivity occurs in pods with ratios of length:width that vary from 4:1 to > 10:1. There is no field or petrographic evidence to suggest that the radioactive pods were originally intrusive.

71 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Carpenter, R.; Beasley, T. M., 1981, Plutonium and americium in anoxic marine sediment: Evidence against remobilization: Geochimica et Cosmochimica Acta, v. 10, p. 1917-1930.

C) Purpose: compare observed concentrations of Pu and Am in sediment vs. atmospheric input, and assess effects of oxidation potential on mobility.

Methods: chemical methods, INAA, Si-surface barrier detection, low background anti-coincidence beta counting.

Results: ^{241}Am/$^{239+240}$Pu in anoxic inlet is in agreement with ratios found in northern midlatitude fallout and with other anoxic basins studied. Comparison to oxic basin indicate that Pu is not rapidly mobilized in anoxic sediments. Sedimentary Pu activity reached a peak in 1970-1973, about 7 years after peak fallout.

72. A) Gen. Cat.--Behavior of actinides in geomedia

B) Dickinson, K. A., 1981, Geologic controls of uranium mineralization in the Tallahassee Creek uranium district, Fremont County, Colorado: Mountain Geologist, v. 18, no. 4, p. 88-95.

C) Purpose: present a preliminary discussion of controls on U-mineralization in the Tallahassee Creek district.

Methods: petrography, XRD, NAA.

Results: primary source rock for these deposits is an Oligocene tuff. Leaching and transport of U occurred in alkaline, oxidizing groundwater. Precipitation of U was due to reduction and was controlled by carbonaceous material and pyrite. Localization of the ore was controlled by ground water flow and distribution of organic material. The ore was precipitated as uraninite or coffinite. Some U VI may have been immobilized by sorption on opal or iron oxide.

73 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Giblin, A. M.; Batts, B. D.; Swaine, D. J., 1981, Laboratory simulation studies of uranium mobility in natural waters: Geochimica et Cosmochimica Acta, v. 45, no. 5, p. 699-709.

C) Purpose: consider factors that control U mobility at 25°C.

Methods: spectrophotometric analyses of results from 3 simulations of natural conditions including: 1)hydrous ferric oxide; 2) kaolinite; 3) CO_2.

Results: hydrous ferric oxide and kaolinite affected mobility, but in different Eh-pH domains. Aqueous carbonate increased mobility of U. U mobility under Eh-pH conditions that dictate the presence of an insoluble phase can be explained if the solid phases are present as colloids.

74 A) Gen. Cat.--Behavior of actinides in geomedia

B) Leventhal, J. S., 1981, Pyrolysis gas chromatography - mass spectrometry to characterize organic matter and its relationship to uranium content of Appalachian Devonian black shales: Geochimica et Cosmochimica, v. 45, no. 6, p. 883-889.

C) Purpose: help define the syngenetic U-organic matter relationship.

Methods: pyrolysis, gas chromatography, mass spectrometry.

Results: organic matter type and U-content ($\leq$ 10-120 ppm) show variations that are related to the identified organic precursor materials vitrinite and the fossil Tasmanites. Samples with high vitrinite component also have high U content. The time of accumulation of U (i.e., from rivers, from seawater, or from sediment) is not known.

75 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Rai, D.; Strickert, R. G.; Moore, D. A.; Serne, R. J., 1981, Influence of americium solid phase on americium concentrations in solution: Geochimica et Cosmochimica Acta, v. 45, no. 11, p. 2257-2265.

C) Purpose: determime controls on Am solubility and mechanisms that can be used to predict Am concentrations in ground waters.

Methods: 60 keV gamma ray counting with intrinsic germanium detector, INAA, alpha spectroscopy, liquid scintillation counting.

Results: solubility-limited Am concentration decreased 10-fold with one unit decrease in pH. K for the reaction $Am_{(soil)} + H^+ \rightleftharpoons Am^+$(aqueous complex) is $10^{-4.12}$. The aqueous phase is likely to be $Am(OH)_2^+$. Soil Am is probably not $Am(OH)_3$. Sorption coefficients are controlled by Am precipitation.

76 . A) Gen. Cat.--Behavior of actinides in geomedia.

B) Weber, F. F., Jr.; Sackett, W. M., 1981, Uranium geochemistry of Orca Basin: Geochimica et Cosmochimica Acta, v. 45, no. 8, p. 1321-1329.

C) Purpose: compare and contrast U concentrations in this basin with 3 other anoxic basins.

Methods: delayed-neutron counting.

Results: high U contents are associated with low organic matter contents and δ^{13}C. U concentrations ranged from 2.1-4.1 ppm. Anoxic conditions are necessary for significant U uptake by non-carbonate sediments. Other significant factors in hypersaline basin sediments include: dilution by deposition in minerals, outside U supply.

77 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Alekseyev, V. A.; Klassova, N. S.; Prisyagina, N. I.; Volodina, Y. A.; Rafal'skiy, R. P., 1982 , Interaction of sulfuric acid solutions with carbonates and feldspar in the underground leaching of uranium: Geochemistry International, v. 19, no. 3, p. 177-185.

C) Purpose: estimate role of carbonates and alkali feldspars in neutralizing H_2SO_4 solutions.

Methods: flame photometry, AAS, colorimetry, volumetric method.

Results: reaction with calcite is rapid enough to produce a neutral solution within a few days, if enough calcite is exposed. Reaction with dolomite is initially rapid but slows dramatically after about half of the equilibrium amount of dolomite has reacted. Reaction with feldspar, and effects of feldspar on pH, are minimal. These results can be applied to underground leaching processes used in the recovery of uranium.

78 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Borole, D. V.; Krishnaswami, S.; Somayojulu, B. L. K., 1982, Uranium isotopes in rivers, estuaries, and adjacent coastal sediments of western India: their weathering, transport, and oceanic budget: Geochimica et Cosmochimica Acta, v. 46, no. 2, p. 125-137.

C) Purpose: understand U budget, particularly the amount of ^{238}U in pelagic sediments relative to the amount brought in by rivers.

Method: AAS, alpha spectrometry.

Results: U that is brought in by rivers shows a positive correlation with the total cations (Na + K + Mg + Ca) and with bicarbonate, occurring in ratios that are similar to ratios in typical crustal rock. ^{238}U input is estimated at $.88 \times 10^{10}$g/yr, which is very similar to its estimated removal rate (1.05×10^{10} g/yr). Estuaries with chlorosities > .14g/liter act as neither sources nor sinks for U. Estimates of the amount of U supplied by rivers fall short by about 20% of the amount estimated for the total ocean.

79\. A) Gen. Cat.--Behavior of actinides in geomedia

B) Brindley, G. W.; Bastovanov, M., 1982, Interaction of uranyl ions with synthetic zeolites of type A and the formation of compreignacite-like and bacquerellite-like products: Clays and Clay Minerals, v. 30, no. 2, p. 135-142.

C) Purpose: examine reactions between uranyl ions and type A zeolites.

Methods: XRD, AAS.

Results: reaction between uranyl acetate and Na- or K- A zeolite resulted in the formation of a crystalline product resembling compreignacite ($K_2O \cdot 6UO_2 \cdot 11H_2O$); reaction with Ca- A zeolite resulted in the formation of becquerelite-like product ($CaO \cdot 6UO_3 \cdot 11H_2O$). If the U concentration exceeded 3700 ppm, only X-ray amorphous products were obtained.

80 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Crozaz, G.; Sibley, S. F.; Tasker, D. R., 1982, Uranium in the silicate intrusions of stony-iron and iron meteorites: Geochimica et Cosmochimica Acta, v. 46, no. 5, p. 749-754.

C) Purpose: study the silicate fraction of meteorites.

Methods: microprobe, fission track techniques.

Results: concentrated U is usually found in the phosphates merrillite and/or chlorapatite. Some of the meteorites studied contain no U; U concentrations varied greatly from sample to sample. Pu and U,and Th and U were fractionated at time of formation in one meteorite.

81 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Devina, O.A.; Yefimov, M. Y.; Medvedev, V. A.; Khodakovskiy, I. L.,1982, Thermodynamic properties of the uranyl ion in aqueous solutions at elevated temperatures: Geochemistry International, v. 19, no. 5, p. 161-172.

C) Purpose: refine the thermodynamic data on $UO_2^{2+}{}_{(sol)}$.

Methods: calorimetry.

Results: all for UO_2^{2+} (sol)

$\_H^{o}_{f\ 298.15} = -1019.62 \pm 1.34$ kJ/mol

$\_H^{o}_{T} = 67873.5 + (678.7)T - (1.297)T^2$ J/mol

$\bar{c}^{o}_{p_2} = 63.55 - (1.90)T$ J/mol·deg

82. A) Gen. Cat.--Behavior of actinides in geomedia

B) Fleischer, R. L., 1982, Alpha-recoil damage and solution effects in minerals: uranium isotopic disequilibrium and radon release: Geochimica et Cosmochimica Acta, v. 46, no. 11, p. 2191-2201.

C) Purpose: evaluate effects of time and annealing temperature on solution effects.

Methods: fission-track activation .

Results: virtually any solution will remove a significant fraction of alpha-recoil nuclei that have entered a mineral; the amount increases with time. Two mechanisms have been identified: 1) recoil ejection from grains, 2) release by natural etching of alpha-recoil tracks. Radon emanation may occur by these same mechanisms.

83. A) Gen. Cat.--Behavior of actinides in geomedia

B) Hattori, K; Halas, S., 1982, Calculation of oxygen isotope fractionation between uranium dioxide, uranium trioxide, and water: Geochimica et Cosmochimica Acta, v. 46, no. 10, p. 1863-1868.

C) Purpose: express "mass effect" tendency in oxides quantitatively in terms of reduced partition function ratios (rpfr).

Methods: calculations based on previously determined data.

Results: rpfr for both U-oxides are lower than that for H_2O (uranite is depleted in ^{18}O relative to H_2O). U-rpfr values are similar to those of other metal oxides, such as magnetite and rutile.

Fractionation factors:

$$\alpha UO_3 : 10^3 \ln\alpha = 3.29 \frac{10^6}{T^2} - 13.63 \frac{10^3}{T} + 4.65$$

$$UO_2 : 10^3 \ln\alpha = 3.63 \frac{10^6}{T^2} - 13.29 \frac{10^3}{T} + 4.42$$

84. A) Gen. Cat.--Behavior of actinides in geomedia

B) Shanbhag, P. M.; Morse, J. W., 1982, Americium interaction with calcite and aragonite surfaces in seawater: Geochimica et Cosmochimica Acta, v. 46, no. 2, p. 241-246.

C) Purpose: understand the interaction of radionuclides with specific sediment components.

Methods: XRD, automatic liquid scintillation counting.

Results: Am is rapidly and strongly adsorbed, even at low concentrations. Minimum K_D is 2×10^5. Adsorption is 40 times as fast on synthetic aragonite as on synthetic calcite. Adsorption rate is dependent on surface area and Mg content of mineral.

85 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Starinsky, A.; Katz, A.; Kolodny, Y., 1982, The incorporation of uranium into diagenetic phosphorite: Geochimica et Cosmochimica Acta, v. 46, no. 8, p. 1365-1374.

C) Purpose: model the behavior of U during the diagenetic formation of marine phosphorite.

Methods: calculations based on previously published data.

Results: the model involves a dissolution-reprecipitation replacement of hydroxyapatite, calcium carbonate, and earlier generated francolite by francolite. Final U concentration is controlled by the amount of organic matter consumed, the replacement reaction process, and the amount of U in the dissolved phases. The partition coefficient between apatite and interstitial solution is $\lambda_U^F = 0.57$. Natural phosphorites are in good agreement with this model.

86 . A) Gen. Cat.--Actinide behavior

B) Ames, L. L.; McGarrah, J. E.; Walker, B. A.; Salter, P.F., 1983, Uranium and radium sorption on amorphous ferric oxyhydroxide: Chemical Geology, v. 40, no. 1/2, p. 135-148.

C) Purpose: to demonstrate quantitatively the effects of temperature, uranyl cation concentration and solution bicarbonate concentration on the uranyl cation sorption efficiency of freshly precipitated ferric oxyhydroxides, and to compare uranium sorption to radium sorption under the same experimental conditions.

Methods: Sorption studies, XRD.

Results: uranium distribution coefficients ranged from more than 2×10^6 ml g^{-1} from 0.01 M NaCl at 25°C to about 3×10^4 ml g^{-1} from 0.01 M $NaHCO_3$ at 25°C and fell rapidly with increasing U solution concentration. The uranium sorption data fit a Dubinin-Radush-Kevich sorption isotherm.

The radium sorption data fit a Freundlich sorption isotherm with radium distribution coefficients ranging from a low of about 1100 ml g^{-1} at 60°C to a high of $<$20,000 ml g^{-1} at 25°C, much lower than comparable uranium distribution coefficients .

87. A) Gen. Cat.--Behavior of actinides in geomedia

B) Benjamin, T. M.; Jones, J. H.; Heuser, W. R.; Burnett, D. S., 1983, Laboratory actinide partitioning: Whitlockite/liquid and influence of actinide concentration levels: Geochimica et Cosmochimica Acta, v. 47, no. 10, p. 1695-1705.

C) Purpose: deduce the U-substitution mechanism in whitlockite (β Ca-phosphate).

Methods: electron microprobe, fission and alpha track radiography.

Results: under reducing conditions, Pu^{3+} is more readily incorporated than U^{4+} or Th^{4+}. Partition coefficients for whitlockite (estimated) for Pu^{3+}, Pu^{4+}, Th^{4+}, U^{4+}, U^{6+} are:

3.6 / $< \leq$ 0.6 / 1.2 / 0.5 / $\leq$ 0.002.

Most probable mechanism for substitution is: $U + 2Si \rightleftharpoons Ca + 2P$.

88\. A) Gen. Cat.--Behavior of actinides in geomedia

B) Davina, O. A.; Yefimov, M. Y.; Medvedev, V. A.; Khodakovskiy, I. L., 1983, Thermochemical determination of the stability constant of $UO_2(CO_3)_3^{4-}$ (sol) at 25-200°C: Geochemistry International, v. 20, no. 3, p. 10-18.

C) Purpose: establish the stability of UTC at a range of temperatures.

Methods: calorimetry.

Results:

$$\Delta H^{o}_{f:298.15} UO_2(CO_3)_3^{4-}{}_{(sol)} = -3085.5 \pm 1.7 \text{ kJ/mol}$$

$$\Delta H^{o}_{T} = (379.4 \pm 58.0)T - (153727.8 \pm 17300) \text{ kJ/mol}$$

$$\Delta G^{o}_{T} = (-153727.8) + (2267.9)T - (379.4)T(\ln T)$$

$$\log \beta^{o}_{s} = 8029.9/T - 118.46 + (19.82) \ln T$$

89 . A) Gen. Cat.--Uranium

B) Dostal, J.; Dupuy, C.; and Keppie, J. D., 1983, Uranium and thorium in Paleozoic rhyolites of Nova Scotia: Canadian Journal of Earth Sciences, v. 20, no. 2, p. 266-274.

C) Purpose: to present some geochemical data, particularly on U and Th in the Paleozoic rhyolitic rocks of Nova Scotia that were subjected to low-grade regional metamorphism.

Methods: petrography, chemical analyses (XRF, AA)

Results: the abundances of U and Th in Paleozoic rhyolites from Nova Scotia are related to their contents of K. Their distribution is strongly affected by secondary (probably low-grade metamorphic) processes, which could lead either to enrichment or depletion.

90. A) Gen. Cat.--Behavior of actinides in geomedia.

B) Murrell, M. T.; Burnett, D. S., 1983, The behavior of actinides, phosphorous, and rare earth elements during chondrite metamorphism: Geochimica et Cosmochimica Acta, v. 47, no. 11, p. 1999-2014.

C) Purpose: gain a better understanding of Pu/U in certain meteorites (H-chondrites, type 3-5).

Methods: fission track radiography, SEM, literature review.

Results: 5 meteorites were studied.

U in Ca-phosphates: lower than average in 3 of 5 samples; none found in the other 2.

U in chondrule mesostasis: U enrichment is common but amount varies considerably.

^{244}Pu distribution: based on track retention in olivine, ^{244}Pu was considerably less than expected based on measured U concentrations. $Pu_{(merrillite)}/Pu_{(apatite)} = 3 \pm 1$.

Merrillite is the dominant Pu host phase; chondrule mesostasis is the U host while phosphates have negligible U concentrations.

91 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Santschi, P. H.; Yuan-Hui, L.; Alder, D. M.; Amdurer, M.; Bell, J.; Nyffeler, U. P., 1983, The relative mobility of natural (Th, Pb and Po) and fallout (Pu, Am, Cs) radionuclides in the coastal marine environment: results from model ecosystems (MERL) and Narragansett Bay: Geochimica et Cosmochimica Acta, v. 47, no. 2, p. 201-210.

C) Purpose: investigate in detail the relative mobility of radionuclides in water and in bioturbated oxic sediments.

Methods: gamma spectrometry with Ge(Li) detector, alpha spectrometry.

Results: mobility of ^{210}Pb, ^{234,228}Th, and ^{239,240}Pu is controlled by attraction to particles and mobility of these particles. Thus particle matter concentration and flux are very important in determining the fate of these elements. Cs is much more mobile than other elements in the study. Relative mobilities: $^{236}\mathrm{Pu} < {}^{228}\mathrm{Th} \approx {}^{210}\mathrm{Pb} < {}^{59}\mathrm{Fe} < {}^{54}\mathrm{Mn} \not\approx {}^{137}\mathrm{Cs}$. Short term experiments such as this one cannot explain the behavior of elements, such as Po, with long cycling times.

92. A) Gen. Cat.--Behavior of actinides in geomedia

B) Shirvington, P. J., 1983, Fixation of radionuclides in the ^{238}U decay series in the vicinity of mineralized zones: 1. The Austatom Uranium Prospect, Northern Territory, Australia: Geochimica et Cosmochimica Acta, v. 47, no. 3, p. 403-412.

C) Purpose: study U decay chain members in field to draw analogies to nuclear waste repositories.

Methods: INAA, delayed neutron counting, alpha spectrometry, fluorimetry, leaching tests. Samples were 6 drill cores.

Results: fractionation of ^{234}U and ^{238}U during decay preferentially retarded or accelerated dissolution of ^{234}U from kaolinite as a function of the presence of mixed layer clays. U residence times of at least 3.6 x 10^5 years are indicated. Clays show excellent longterm retention of U, even under strongly oxidized conditions and with abundant groundwater present. Leaching curves indicate substitution of U into clay mineral lattices.

93 . A) Gen. Cat.—Actinide behavior

B) Morse, J. W.; Shanbhag, P. M.; Saito, A.; Choppin, G. R., 1984, Interaction of uranyl ions in carbonate media: Chemical Geology, v. 42, no. 3/4, p. 85-99.

C) Purpose: to investigate the interaction of uranyl, UO_2^{2+}, in seawater and in dilute aqueous solutions with calcium carbonate minerals.

Methods: adsorption studies, spectrophotometric measurements.

Results: the reaction sequence encountered in this study may play an important role in controlling UO_2^{2+} behavior in geologic systems. The results indicate that the transition from hydroxyl to carbonate UO_2^{2+} species can be accompanied by removal of UO_2^{2+} from solution onto carbonate minerals surfaces. During this part of the reaction, the uranium is strongly concentrated on the carbonate mineral surface. Once absorbed, it may be more susceptible to mineralization by other common components, but UO_2^{2+} may still be released back into solution. This release is accompanied by carbonate mineral dissolution.

94 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Rama; Moore, W. S., 1984, Mechanism of transport of U-Th series radioisotopes from solids into groundwater: Geochimica et Cosmochimica Acta, v. 48, no. 2, p. 395-399.

C) Purpose: understand the mechanism of release of ^{222}Rn and ^{220}Rn from material usually found in productive aquifers.

Methods: samples of saprolite, aquifer core (quartz and pore water) and monozite-rich sand were examined for Rn, Pb, and Bi using an evacuated scintillation counting chamber, or a Ge(Li) detector, or a well type Germanium detector. Texture of samples was examined with SEM.

Results: 1) Rn and other daughters of U-Th decay are introduced into nanopore water as a result of recoil from walls of nanopores in solids. Radon diffuses out while reactive daughters are sorbed. 2) Migration from intergranular to nanopore water occurs on a time scale of one day. Sorption can then take place. 3) Sorption of daughters in intergranular region cannot be estimated because of uncertainties in supply rate.

95 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Petit, J-C.; Langevin Y.; Dran, J-C, 1985, Radiation-enhanced release of uranium from accessory mineral in crystalline rocks: Geochimica et Cosmochimica Acta, v. 49, no. 3, p. 871-876.

C) Purpose: assess role of alpha decay on rate of U release.

Methods: optical microscopy, Talystep diamond stylus device.

Results: simulated increase in alpha-recoils greatly increases the dissolution rate of U-bearing minerals. This phenomenon indicates a threshold due to the accumulation of defects above a critical concentration.

96 . A) Gen. Cat.--Behavior of actinides in geomedia

B) Torgersen, T.; Clarke, W. B.; Helium accumulation in groundwater, I: An evaluation of sources and the continental flux of crustal ^{4}He in the Great Artesian Basin, Australia: Geochimica et Cosmochimica Acta, v. 49, no. 5, p. 1211-1218, 1985.

C) Purpose: discuss possible sources for He and rate of He accumulation.

Methods: mass spectrometer.

Results: measured ^{4}He accumulation rate is in close agreement with that calculated using U and Th production rates, assuming U = 1.7 ppm and Th = 6.1 ppm in the aquifer. Weathering input of ^{4}He is insignificant.

1. A) Gen. Cat.--Clay minerals

   B) Grim, R. E.; Kulbicki, G., 1961, Montmorillonite: high temperature reactions and classification: American Mineralogist, v. 46, no. 11 and 12, p. 1329-1369.

   C) Purpose: to study the successive structural changes taking place when members of the montmorillonite group of clay minerals are heated to their fusion temperature.

   Methods : continuous high-temperature XRD.

   Results: the high-temperature phase transformations of montmorillonite show large variations depending on the composition and structure of the original material. All of the analytical data indicate that the dioctahedral montmorillonites do not form a single continuous isomorphic series. Two different aluminous types have been found, Cheto- and Wyoming types, which differ primarily in the population of their octahedral layers.

2. A) Gen. Cat.--Behavior of clays in geomedia

   B) Bredehoeft, J. D.; Blyth, C. R.; White, W. A.; Maxey, G. B., 1963, Possible mechanism for concentration of brines in subsurface formations: American Association of Petroleum Geologists Bulletin, v. 47, no. 2, p. 257-269.

   C) <u>Purpose</u>: suggest a mechanism for the concentration of brines in the subsurface.

   <u>Methods</u>: calculations based on published data

   <u>Results</u>: similarities between actual concentration profiles and those predicted by the model "is striking." It is especially good for low concentrations, but the model is applicable to a range of initial concentrations. Formation of brines may be through retention of cations on negatively charged surfaces.

"RADWASTE NATURAL ANALOG CATALOG"

Introduction

This project was undertaken under Contract 19X-27435V between Martin Marietta Energy Systems, Inc. (via Oak Ridge National Laboratory) and the University of New Mexico.

The purpose of this contract was to attempt to catalog, from the open literature, as many as possible studies that may be of use to the studies of radioactive waste disposal. The approach has been to identify studies of actual rock systems that may serve as natural analogs for such radwaste studies, even though the purpose of such studies was not aimed at waste disposal. To carry out this task, the Principal Investigator assembled a team of graduate students, Messrs Robert Beard, John Persico, Bruce Patacky to canvass the literature and provide written summaries of articles relevant to this project. The Principal Investigator also canvassed literature and, in most cases, reviewd the written comments of the others. The material was typed by Ms. Rebecca Smith.

The information thus obtained was, in as much as possible, reported in the format given below:

GENERAL CATAGORY

- Igneous intrusions
  - --major plutons; contact effects
  - --minor intrusions (mainly dikes); contact effects (intruded media include basalt, tuff, and bedded salt)
- Active and semi-dormant geothermal systems
- Areas of hydrothermal alteration
  - --accompanying ore deposition
  - --minor veins of mineralization(focus on elemental distribution, mobilization, mechanisms for retardation-retention)
- Behavior of clay minerals in geomedia
  - --alteration studies in bedded salts, tuffs and basalt

REFERENCE: Complete listing of the source of information; author(s), title, journal, pagination, year

BACKGROUND ON STUDY

- Purpose of investigation
- Methods used (e.g. petrography, chemical, other)
- Summary of results

The scope of the project, however, was broadened to include potential analog work in many other areas (See Table of Contents on page IV). This was done in order to make this cataloging effort as comprehensive as possible.

The journals inspected during this study are listed separately (page III).

The article summaries are each given on a separate page for ease of referencing, and they are reported in the following order: Actinides, Clay Minerals, Contact Metamorphism, Element Mobility, Fractures, Glasses and Nuclear Waste Studies, Hydrothermal Alteration, Hydrothermal Deposits, Hydrothermal Fluids, Hydrothermal Systems, Ingeous Contact Effects, Metamictization, Mineral Solubilities, Minor Intrusions-contact effects, Miscellaneous, Repository rocks, Skarns, Sorption, Vein Deposits, Zeolites. One thousand ninety three entries are included in this report.

It should be emphasized that not included are the following:

1. Abstracts (i.e. too little information given)
2. Articles from symposia, meetings, etc. addressing natural analogs for radwaste studies (i.e. redundant)
3. Theses and dissertations
4. Technical reports (i.e. the material here is already identified as a natural analog study, etc.)
5. Material published in the non-refereed literature.

In addition, it should be stressed that the 1093 entries to follow are not ranked, as this will be done as part of a follow-up study

3 . A) Gen. Cat.--Clay behavior

B) Veniale, F.; van der Marel, H. W., 1963, An interstratified saponite-swelling chlorite mineral as a weathering product of lizardite rock from Sr. Margherita staffora (Pavia Province), Italy: Contributions to Mineralogy and Petrology, v. 9, p. 198-245.

C) Purpose: to determine clays in serpentinite rock.

Methods: microscopy, chemical analysis, electron microscopy, x-ray and infra-red spectroscopy.

Results: swelling chlorite, a weathering product of lizardite, was identified and proved to be an intermediate stage in this weathering process.

4. A) Gen. Cat.--Behavior of clays in geomedia

B) Adams, W. L., 1964, Diagenetic aspects of lower Morrowan, Pennsylvanian, sandstones, northwestern Oklahoma: American Association of Petroleum Geologists Bulletin, v. 48, no. 9, p. 1568-1580.

C) Purpose: identify, describe, and classify diagenetic aspects of Morrowan age rocks in northwestern Oklahoma.

Methods: petrography.

Results: diagenetic "facies" are present and are potentially mappable in these rocks. Clayey sandstones lacked original porosity, but secondary porosity developed. Most clay in these beds is primary; however, some is diagenetic.

5. A) Gen. Cat.--Behavior of clays in geomedia

B) Halevy, E., 1964, The exchangeability of hydroxyl groups in kaolinite: Geochimica et Cosmochimica Acta, v. 28, no. 7, p. 1139-1145.

C) Purpose: investigate anion exchange using water marked with isotopes (T and ^{18}O).

Methods: Geiger counter, liquid scintillation counting, mass spectrometry.

Results: per cent exchange $\leq 1\%$. Changes in pH from 4 to 6 have no effect. The extent of the reaction can explain the exchange of a few milliequivalents OH per 100g kaolinite.

6. A) Gen. Cat.--Delaware Basin; Clay minerals; Bentonites, Permian

B) Dahl, H. M., 1965, Clay mineralogy of some Permian bentonites from the Delaware Basin area, Texas: American Mineralogist, v. 50, no. 10, p. 1637-1646.

C) Purpose: to note the wide variations in clay mineral content found in closely associated bentonites in the Cherry Canyon Formation.

Methods: Petrography, XRD.

Results: X-ray diffraction analyses indicate that these bentonites, unlike most closely associated bentonites, vary markedly in clay mineral types. The prominent clay minerals noted are: chlorite, illite, randomly mixed-layered illite-montmorillonite, and mixtures of illite and montmorillonite..

7 . A) Gen. Cat.-- Clay minerals, montmorillonite, pseudomorphs

B) Fournier, R. O., 1965, Montmorillonite pseudomorphs after plagioclase in a porphyry copper deposit: American Mineralogist, v. 50, no. 5 and 6, p. 771-777.

C) Purpose: to investigate montmorillonite pseudomorphs after plagioclase to see where they lay in the montmorillonite-beidellite group and to examine various determinative techniques in the light of the composition.

Methods: chemical analyses, XRD, differential thermal analysis, density measurements.

Results: the host rock was initially a quartz monzonite or monzonite. In the montmorillonite-bearing rock orthoclase is unaltered, hornblende alters to biotite and chlorite, and plagioclase altered mainly to montmorillonite. No differences could be detected in the respective optical, x-ray, and DTA characteristics among the montmorillonites in three rock samples.

8 A) Gen. Cat.--Clay minerals, thermal expansion

B) Mckinstry, H. A., 1965, Thermal expansion of clay minerals:
American Mineralogist, v. 50, no. 1 and 2, p.212-222.

C) Purpose: to measure the thermal expansion coefficients of several clay minerals.

Methods: x-ray techniques.

Results: the thermal expansion for several of the layer minerals has been found to be anisotropic. However, there is no clear relationship between the thermal expansion of the minerals and the usual crystal chemistry parameters.

9. A) Gen. Cat.--Clay minerals, mixed layer

B) Oinuma, K.; Hayashi, H., 1965, Infrared study of mixed-layer clay minerals: American Mineralogist, v. 50, no. 9, p. 1213-1227.

C) Purpose: to discuss the infrared absorption spectra of various kinds of mixed layer clay minerals from Japan which were previously studied in detail by x-ray and other methods.

Methods: infrared absorption spectrometry

Results: The infrared absorption spectra of these mixed-layer clay minerals overlap those of the respective constituents of each mixed layer minerals (sic); this fact agrees well with the results obtained through x-ray analysis and other methods.

10 . A) Gen. Cat.-- Clay minerals, illite, montmorillonite

B) Roberson, H. E.; Jonas, E. C., 1965, Clay minerals intermediate between illite and montmorillonite: American Mineralogist, v. 50, no. 5 and 6, p. 766-770.

C) Purpose: to describe a clay mineral that may be intermediate in the series between montmorillonite and illite.

Methods: XRD, cation exchange capacity measurements.

Results: the material described is composed of a range of particle size crystallites in the coarse montmorillonite part of the series. Its size and charge are somewhat smaller than those of illite or the stripped mica as is indicated by the replaceability of the cations. The crystallite size and charge are greater than those of montmorillonite as is indicated by its resistance to expansion.

11 . A) Gen. Cat.--Clay minerals, expansion

B) Sayegh, A. H.; Harward, M. E.; Knox, E. G., 1965, Humidity and temperature interaction with respect to K-saturated expanding clay minerals: American Mineralogist, v. 50, no. 3 and 4, p. 490-495.

C) Purpose: to investigate the effects of humidity and temperature on K-saturated expanding minerals.

Methods: XRD.

Results: the sensitivity of d_{001} of K-saturated smectite to relative humidity emphasizes rates of rehydration micas, vermiculites, and smectites. Diffraction patterns of K-saturated clay without humidity control are ambiguous.

12. A) Gen. Cat.--Clay minerals, kaolin, water

B) Wada, K., 1965, Intercalation of water in kaolin minerals: American Mineralogist, v. 50, no. 7 and 8, p. 924-941.

C) Purpose: to clarify the relationships between the fixation and hydration reactions.

Methods: XRD.

Results: the observed differences in intercalation between the polymorphic varieties may be taken as an indication of a structural control over the intercalation since other factors, such as the presence of interlayer cations, cannot have importance here. This view is consistent with the previous conclusions that the intercalation is in nature a molecular association and that the geometrical relationships between the interlayer material and mineral surface structure is of primary importance.

13 . A) Gen. Cat.--Clay minerals, dehydroxylation

B) Weber, J. N.; Rustum, R., 1965, Dehydroxylation of kaolinite, dickite, and halloysite: heats of reaction and kinetics of dehydration at p_{H_2O}=15psi: American Mineralogist, v. 50, no. 7 and 8, p. 1038-1045.

C) Purpose : to present the results of 51_H determinations of 9 samples of kaolinite, 5 samples of halloysite and 1 specimen of dickite dehydrated at P_{H_2O}= 15 psi.

Methods: differential thermal analysis, chemical analyses (XRF)

Results: values of the enthalpy of dehydration are 151, 156, and 160 cal/gm for kaolinite, dickite, and halloysite, respectively. Activation energies for dehydration at a water pressure of 15 psi are considerably greater than published activation energies determined at much lower water vapor pressures.

14 . A) Gen. Cat.--Behavior of clays in geomedia

B) Young, A.; Low, P. F., 1965, Osmosis in argillaceous rocks:American Association of Petroleum Geologists Bulletin, v. 49, no. 7, p. 1004-1008.

C) Purpose: examine osmotic flow through undisturbed rock.

Methods: osmometer.

Results: osmotic flow occurred at pressures far less than theoretically expected. This was explained by the prescence of microcracks and pores in the sample disks.

15 . A) Gen. Cat.—Clay behavior

B) Chatterjee, N. D., 1966, On the widespread occurrence of oxidized chlorites in the Pennine zone of the Western Italian Alps: Contributions to Mineralogy and Petrology, v. 12, p. 325-339.

C) Purpose: to describe and determine petrogenesis of the clay.

Methods: optical, x-ray, chemical, DTA, and infrared spec. techniques.

Results: oxidized chlorites have optical properties similar to biotite, stilpnomelane or iron-rich vermiculite. The chlorite was determined to have undergone an internal oxidation. Petrogenesis is discussed.

16. A) Gen. Cat.--Clay minerals, kaolinite-halloysite

B) de Souza Santos, P.; de Souza Santos, H.; Brindley, G. W., 1966, Mineralogical studies of kaolinite-halloysite clays: Part IV, A platy mineral with structural swelling and shrinking characteristics: American Mineralogist, v. 51, no. 11 and 12, p. 1640-1648.

C) Purpose: to report a kaolinite-group mineral which in electron micrographs is seen to consist of fine platy particles in which no tubular particles can be detected.

Methods: chemical analyses, differential thermal analysis, XRD, electron microscope.

Results: the material under consideration is a kaolinite-group mineral exhibiting some of the characteristics of kaolinite (notably a platy habit, and ability to orient with respect to (001) and also of endellite (10 Å spacing which collapses to 7.3 Å with gentle heating, expansion in ethylene glycol, and a diffraction pattern indicating highly random layer displacements parallel to (001)).

17 . A) Gen. Cat.--Clay minerals, exchange equilibria

B) Eliason, J. R., 1966, Montmorillonite exchange equilibria with strontium-sodium-cesium: American Mineralogist, v. 51, no. 3 and 4, p. 324-335.

C) Purpose: to determine several exchange isotherms and associated free energy changes for a montmorillonite of hydrothermal origin, and to make a comparison of the exchange characteristics of two montmorillonites of different origin.

Methods: chemical analyses, electron microscope, cation exchange capacity measurements, free energy change measurements.

Results: the exchange isotherms for the strontium-sodium, cesium-sodium and cesium-strontium systems show that both montmorillonites have a preference for cesium over sodium and that a preference for strontium over sodium and cesium over strontium is shown by the Bayard, New Mexico montmorillonite.

18 . A) Gen. Cat.--Clay minerals, illite, sorption, cesium

B) Gaudette, H. E.; Grim, R. E.; Metzger, C. F., 1966, Illite: A model based on the sorption behavior of cesium: American Mineralogist, v. 51, no. 11 and 12, p. 1649-1656.

C) Purpose: to discuss the factors which apparently control the sorption of Cs by illite correlated to structural and chemical variations in the natural 10 Å clay minerals in the light of a proposed model for illite.

Methods: chemical analyses, XRD.

Results: the sorption behavior of Cs is considered to be primarily due to the competition of Cs with other ions in respect to potassium or potassium-depleted sites of the skeletal "incoherent" rind portion of the illite.

19. A) Gen. Cat.--Clay minerals

B) Hower, J.; Mowatt, T. C., 1966, The mineralogy of illites and mixed-layer illite/montmorillonite: American Mineralogist, v. 51, no. 5 and 6, p. 825-854.

C) Purpose: to discuss the mineralogical aspects of the montmorillonite-mixed layer illite/montmorillonite series and its relationship to the trisilicic-tetrasilic dioctahedral mica series of Foster (1956).

Methods: XRD, chemical analyses (x-ray spectrographic techniques), cation exchange capacity measurements .

Results: montmorillonites, mixed-layer illite/montmorillonites, and illites form a continuous mineralogical sequence in which the composition and structure are nicely related. The illite end of the sequence appears to be distinct from true dioctahedral micas. The compositional range of this mineral group within the limits pyrophyllite-muscovite-celadonite indicates that the group deserves a petrological interpretation different from that of degraded high temperature dioctahedral micas.

20. A) Gen. Cat.--Behavior of clays in geomedia

B) Khitarov, N. I.; Pugin, V. A., 1966, Behavior of montmorillonite under elevated temperatures and pressures: Geochemistry International, v. 3, no. 4, p. 621-627.

C) Purpose: discover the depths and temperatures under which water is liberated from hydrous minerals.

Methods: petrography, XRD.

Results: in areas where the geothermal gradient is 15°C/km, montmorillonite should persist down to 9 km; if the geothermal gradient is 20-30°C/km, montmorillonite should be preserved at depths of 3-6 km. The transformation of montmorillonite to hydromica can take place over a considerable range of depths, but only in the presence of potassium.

21 . A) Gen. Cat.--Micas, dehydroxylation

B) Nakahira, M.; Uda, M., 1966, Electron-microscopic observation of dehydroxylated micas: American Mineralogist, v. 51, no. 3 and 4, p. 454-463.

C) Purpose: to examine transmission electron-microscopic patterns of dehydroxylated muscovite and phlogopite in a hope that the different dehydroxylation mechanisms of these micas might be revealed through observations of the strain fields in the specimens..

Methods: electron microscope.

Results: in general, unidimensional line contrasts were representative of muscovite patterns while clusters of irregularly shaped light-and-dark contrasts were scattered in several places in phlogopite. The origin of these different contrast effects could be attributed to a difference in the development of strain fields between these dehydroxylated micas; and this, in turn, indicated a difference between the dehydroxylation mechanisms of muscovite and phlogopite.

22. A) Gen. Cat.--Clay minerals, montmorillonite, adsorption

B) Weber, J. B., 1966, Molecular structure and pH effects on the adsorption of 13 s-Triazine compounds on montmorillonite clay: American Mineralogist, v. 51, no. 11 and 12, p. 1657-1670.

C) Purpose: to study the effects of pH and molecular structure of 13 triazines on the adsorption of these compounds on montmorillonite clay.

Methods: cation exchange capacity measurements, pH measurements, spectrophotometric titrations.

Results: these studies showed that the adsorption of each of the 13 s-triazine compounds on montmorillonite clay increased with a decrease in pH to approximately the vicinity of the respective pK_A values for each compound. A further lowering of the pH resulted in some desorption of each of the adsorbed s-triazine compounds.

23. A) Gen. Cat.--Clay minerals

B) Weiss, A., and Amstutz, G. C., 1966, Ion-exchange reactions on clay minerals and cation selective membrane properties as possible mechanisms of economic metal concentration: Mineralium Deposita, v. 1, no. 1, p. 60-66.

C) Purpose: to investigate Pb, Zn, Ca, and Cd exchange reactions in clay minerals.

Methods: XRD, cation exchange measurements.

Results: the extraction of Pb, Zn, and Cd from bentonite, illite, kaolinite, and montmorillonite was successful and megascopic quantities of PbS, CdS, and ZnS could be obtained at specific loci, depending essentially on the flow velocity and the other cations present. These or similar exchange reactions are tentatively proposed as possible mechanisms of economic metal concentration during diagenesis.

24 . A) Gen. Cat.--Clay behavior, basalt alteration

B) Baker, I.; Haggerty, S. E., 1967, The alteration of olivine in basaltic and associated lavas, Part II: Intermediate and low temperature alteration: Contributions to Mineralogy and Petrology, v. 16, p. 258-273.

C) Purpose: to determine products of low and intermediate temperature alteration of olivines in basalt.

Methods: optical and x-ray diffraction analysis of alteration products.

Results: various assemblages of clays (generally chlorites) are described for various conditions of low and intermediate temperature alteration of olivine. Chemistry of the alteration reactions is discussed.

25 . A) Gen. Cat.--Clay minerals, kaolinite; dehydroxylation

B) Brindley, G. W.; Sharp, J. H.; Patterson, J. H.; Narahari, B. N., 1967, Kinetics and mechanism of dehydroxylation processes, I. Temperature and vapor pressure dependence of dehydroxylation of kaolinite: American Mineralogist, v. 52, no. 1 and 2, p. 201-211.

C) Purpose: to reexamine the evidence for a diffusion-controlled mechanism at low vapor pressures and the first-order kinetics generally accepted at higher pressures.

Methods: XRD, mathematical analyses.

Results: the dehydroxylation of kaolinite in the temperature range 400 - 540°C and in water vapor atmospheres from $<10^{-3}$ mm Hg to 175 mm Hg is a diffusion controlled process. The reaction depends not only on processes within the crystalline material, but also on the interaction with the surrounding atmosphere.

26. A) Gen. Cat.--Clay behavior

B) Jones, L. M.; Faure, G., 1967, Origin of the salts in Lake Vonda, Wright Valley, Southern Victoria Land, Antarctica: Earth and Planetary Science Letters, v. 3, p. 101-106.

C) Purpose: to determine origin of salts in Lake Vonda.

Methods: assume Sr isotopes do not fractionate, therefore Sr isotope analysis of various suspected sources composed with Sr isotope ratio in the lake will reveal source.

Results: leaching of soils by glacial melt water provides salts to the lake. All other possiblities are ruled out. Salt composition in the lake is reported to be Na^+ 6761; K^+ 766; Ca^{2+} 24.254; Mg^{2+} 7684; Cl^- 75.870; HCO_3^- 126; and SO_4^{2-} 770 ppm. The soils are formed by chemical weathering of the bedrock in the area (generally igneous and metamorphics).

27 . A) Gen. Cat.—Clay minerals, montmorillonite

B) McAtee, J. L., Jr.; Cheng, F. S., 1967, Differences in apparent interstratification of an organo-montmorillonite dispersed in various organic solvents: American Mineralogist, v. 52, no. 9 and 10, p. 1386-1398.

C) Purpose: to study the effects of various organic solvents on the apparent interstratification of an organo-montmorillonite.

Methods: XRD, Fourier analysis.

Results: a comparison of the physical properties with the Fourier curves and Fourier transform curves at various temperatures showed a general relation between the amount of apparent interstratification with the structure of the solvent and type of interaction between the solvent and the organo-montmorillonite.

28 . A) Gen. Cat.--Clay minerals, kaolinite; montmorillonite

B) Poncelet, G. M.; Brindley, G. W., 1967, Experimental formation of kaolinite from montmorillonite at low temperatures: American Mineralogist, v. 52, no. 7 and 8, p. 1161-1173.

C) Purpose: to investigate the formation of kaolinite by alteration of montmorillonites under various conditions of cations saturation and of acid environments.

Methods: experimental petrology, XRD, infrared absorption spectrometry.

Results: Na- and Al-montmorillonites under hydrothermal conditions at 175° and 220°C for periods of seven days yield no more than very minor amounts of kaolinite and then only under strongly acid conditions.

29 . A) Gen. Cat.--Behavior of clays in geomedia

B) Powers, M. C., 1967, Fluid-release mechanisms in compacting marine mudrocks and their importance in oil exploration: American Association of Petroleum Geologists Bulletin, v. 51, no. 7, p. 1240-1254.

C) Purpose: present a new fluid release mechanism and set limitations on assessment of new potential hydrocarbon production areas.

Methods: literature review.

Results: most water is expelled in montmorillonite by burial to 3,000 feet. Remaining water cannot be expelled by increasing depth. At 3,000, porosity and permeability are virtually zero. Montmorillonite begins to convert to illite at around 6,000 feet and is completed by 10,000. This is accompanied by desorption of H_2O and increase in porosity and permeability. As this water is flushed out, fissility may develop. Desorption of ions at depth may account for increased salinities.

30 . A) Gen. Cat.--Clay minerals, solubility

B) Reesman, A. L.; Keller, W. D., 1968, Aqueous solubility studies of high alumina and clay minerals: American Mineralogist, v. 53, no. 5 and 6, p. 929-942.

C) Purpose: to study the dissolution of high alumina minerals and clay minerals shaken in distilled water at room temperature for periods from 3 to 100 days.

Methods: solubility measurements, pH measurements, chemical analyses (AA, flame omission, spectrography)

Results: dissolution techniques, if carefully applied, can provide useful solubility information that can be utilized in determining the free energy of formation. The free energies of formation for 12 clay minerals were determined.

31. A) Gen. Cat.—Clay minerals, XRD.

B) Reynolds, R. C., Jr., 1967, Interstratified clay systems: calculation of the total one dimensional diffraction function: American Mineralogist, v. 52, no. 5 and 6, p. 661-672.

C) Purpose: to describe a method for calculating X-ray diffraction effects from two-component interstratified clay systems.

Methods: Fourier transforms, XRD.

Results: a preliminary study of the system glycol-montmorillonite-illite indicates that, for very thick crystallites, calculated diffraction angles for most maxima are similar to those computed by other published methods; relative intensities show very large discrepancies. It is suggested that many natural materials may not be randomly interstratified, therefore, the widespread use of the Hendricks-Taller equation for random interstratification may be unjustified.

32. A) Gen. Cat.--Clay behavior

B) Webb , A. W., 1967, A comparison of mineral and whole rock K-Ar ages of Tertiary volcanics from Central Queensland, Australia: Earth and Planetary Science Letters, v. 3, p. 41-47.

C) Purpose: to determine relationship between alteration of volcanic rocks and argon retentivity.

Methods: argon extraction techniques were based on the system described by Evernden and Curtis (referenced in this paper)

Results: no detectable argon leakage was found in basalts and rhyolites (both cogenetic) although most samples were altered to some extent. Where Ar leakage was detected it was associated with increasing alteration of plagioclase and the cryptocrystalline groundmass. An extreme heating is needed to achieve quantitative release of radiogenic Ar from sanadine samples, complete extraction only at temperatures greater than 1650°C.

33 . A) Gen. Cat.--Clay minerals, kaolinite, zeolites

B) De Kimpe, C. R.; Fripiat, J. J., 1968, Kaolinite crystallization from H-exchanged zeolites: American Mineralogist, v. 53, no. 1 and 2, p. 216-230.

C) Purpose: to study the crystallization of kaolinite from H-exchanged zeolites.

Methods: hydrogen-exchange reactions, XRD.

Results: morphological observations suggest that the transformation of hydrogen-exchanged zeolites into kaolinite follows a general pattern whatever the nature of the starting materials but that the rate of change is appreciably different from one structure to another. The transformation occurs in four stages: 1) fragmentation of the initial material into small particles, 2) aggregation of these small elements, 3) formation of thin, partially rolled sheets, and 4) unrolling and formation of thicker two-dimensional sheets.

34. A) Gen. Cat.--Behavior of clays in geomedia

B) Truesdell, A.H.; Christ, C.L., 1968, Cation exchange in clays interpreted by regular solution theory: American Journal of Science, v. 266, no. 5, p. 402-412.

C) Purpose: determine mechanisms of cation exchange in clays.

Methods: calculations based on published data.

Results: single hydrogen clays behave as a mixture of 2 weak acids; each clay contains 2 sets of energetically different exchange sites. Exchange constants agree with those published previously. The model presented for this data will not account for single-site or continuous site clays.

35 . A) Gen. Cat.-- Clay minerals, absorption

B) Weed, S. B.; Weber, J. B., 1968, The effect of adsorbent charge on the competitive adsorption of divalent organic cations by layer-silicate minerals: American Mineralogist, v. 53, no. 3 and 4, p. 478-490.

C) Purpose: to study the competitive adsorption of diquat vs. paraquat on a series of layer silicates differing in surface charge density.

Methods : adsorption studies.

Results : paraquat was preferentially adsorbed on all montmorillonites and on the external surface of vermiculite whereas diquat was preferentially absorbed on the internal surface of vermiculite and on the external surface of nonexpanded mica.

36 . A) Gen. Cat.--Clay behavior, basalt interaction

B) Barshad, I.; Kishk, F. M., 1969, Chemical composition of soil vermiculite clays as related to their genesis: Contributions to Mineralogy and Petrology, v. 24, p. 136-155.

C) Purpose: determination of vermiculite species and their genesis.

Methods: x-ray diffraction analysis.

Results: two types of vermiculite were found in eleven soil samples. One is an aluminous type and the other a silicious type. The aluminous type is derived from breakdown of acid igneous rocks and the silicious type from basic igneous rock breakdown. The mechanisms of these breakdowns are discussed.

37 . A) Gen. Cat.--Clay minerals, montmorillonite

B) Brindley, G. W.; Wiewiora, K.; Wiewiora, A., 1969, Intercrystalline swelling of montmorillonite in some water-organic mixtures (clay-organics. XVII): American Mineralogist, v. 54, no. 11 and 12, p. 1635-1644.

C) Purpose: to study the intracrystalline swelling of Ca-montmorillonite when the composition of the liquid changed progressively from pure water to pure organic.

Methods: XRD measurements of Ca-montmorillonite in equilibrium with mixed water-organic systems.

Results: at critical compositions of the water-organic mixtures, an abrupt decrease of spacing occurs to values near to the spacings of the clay-organic complexes. It is possible that a contributory factor to the collapse is the increased Coulombic attractions due to the diminished dielectric constant of the organic water mixtures.

38 . A) Gen. Cat.--Behavior of clays in geomedia

B) Burst, J. F., 1969, Diagenesis of Gulf Coast clayey sediments and its possible relation to petroleum migration: American Association of Petroleum Geologists Bulletin, v. 53, no. 1, p. 73-93.

C) Purpose: describe the effects of illitization (decrease in bulk density and crystal lattice dimensions) during compaction and its control on petroleum distribution.

Methods: XRD.

Results: dewatering of clays is a 3 step process:

1) Expulsion of pore water and excess (more than 2) water interlayers;

2) Second to last water monolayer;

3) Last water monolayer.

Step 1 is accomplished early in compaction. Step 2 is thermally activated and occurs at 3,000 to 15,000 feet depth. Temperature is the important variable; it is not a "squeezing out." Step 3 progresses very slowly since permeability has been strongly reduced by steps one and two. Like step 1, this is a kinetic process. A dehydration structure surface thus plots similarly to a geothermal gradient map.

39 . A) Gen. Cat--Clay minerals, montmorillonite

B) McAtee, J. L., Jr.; Henslee, W., 1969, Electron-microscopy of montmorillonite dispersed at various pH: American Mineralogist, v. 54, no. 5 and 6, p. 869-874.

C) Purpose: to study montmorillonite dispersions at pH 1 to 13.

Methods: electron microscope

Results: the method is easy and quick, and yields specimens that show the type of particle-particle interaction which occurs in clay dispersions.

40 . A) Gen. Cat.--Clay minerals, kaolinite

B) Mitra, G. B.; Bhattacherjee, S., 1969, X-ray diffraction studies on the transformation of kaolinite to metakaolin: I. Variability of interlayer spacing: American Mineralogist, v. 54, no. 9 and 10, p. 1409-1418.

C) Purpose: to make a detailed study of the variation of the mean fractional change in the interlayer spacing and of the proportion of planes affected by such disorder at different stages of dehydration.

Methods: differential thermal analysis, XRD.

Results: it is observed that the interlayer spacing for the basal planes varies by a constant fraction of the mean value. The disorder originally present in the untreated sample, as variability of interlayer spacings, is increased only at earlier stage. At the next stage, the extent of the disorder remains the same but more planes are affected. Finally, the disorder increases leading to the collapse of the kaolin layer and formation of metakaolin.

41. A) Gen. Cat.--Clay behavior, salt beds

B) Pundeer, G. S., 1969, Mineralogy, genesis, and diagenesis of a brecciated shaly clay from the zechstein evaporite series of Germany: Contributions to Mineralogy and Petrology, v. 23, p. 65-85.

C) Purpose: analysis of core samples from a dolomite-anhydrite sequence.

Methods: x-ray diffraction analysis, petrology, and chemical analysis.

Results: chlorites and illites are the only clay minerals present. Comparison of K_2O content of illites shows regeneration of illite in part of the core. Diagenetic formation of quartz and feldspar is observed. Mechanisms of diagenesisare discussed.

42 . A) Gen. Cat.—Clay behavior; alteration of tuffs and basalt

B) Rosholt, J. N.; Noble, D. C., 1969, Loss of uranium from crystallized silicic volcanic rocks: Earth and Planetary Science Letters, v. 6, p. 268-270.

C) Purpose: to investigate the process of postdepositional mobilization of uranium in silicic volcanic rocks.

Methods: directly comparing the uranium contents of nonhydrated glass and dense, primarily crystallized groundmass material from two welded ash-flow tuff units and one lava unit all Tertiary age, from the western USA.

Results: the primarily crystallized silicic groundmass contains only 20 to 60% of the uranium present in nonhydrated glass. This difference is probably the result of leaching by groundwater and the most crystallized rocks have lost the most U.

43 . A) Gen. Cat.-- clay minerals, illite

B) Thompson, T. D.; Brindley, G. W., 1969, Absorption of pyrimidines, purines, and nucleosides by Na-, Mg-, and Cu(II)-illite. (Clay-organic studies. XVI): American Mineralogist, v. 54, no. 5 and 6, p. 858-868.

C) Purpose: to extend previous work on the absorption of some purines, pyrimidines, and their nucleosides by various cation-saturated montmorillonites.

Methods: cation exchange capacity measurements, gas absorption, organic absorption measurements, pH measurements.

Results: with Na- and Mg-saturated illite, organic absorption occurs mainly under acid conditions by a cation exchange mechanism. The pH of the equilibrating solution for maximum absorption shows a linear relationship to pKa for the formation of protonated molecules. The maximum absorption of different molecules diminishes as pKa diminishes and as more acid conditions are required for protonation.

44 . A) Gen. Cat.--Behavior of clays in geomedia

B) Zierfuss, H., 1969, Heat conductivity of some carbonate rocks and clayey sandstones: American Association of Petroleum Geologists Bulletin, v. 53, no. 2, p. 251-260.

C) Purpose: relate heat conductivity (λ) to composition and geometry of rock body and evaluate if λ can be used to differentiate rock types.

Methods: λ was an average of 5-10 measurements made by placing a sample on a hot copper bar and waiting (about 30 sec.) until T at the interface reached a steady value. This T = λ.

Results: λ for carbonates is a function of rock fabric and porosity. λ for clayey sandstone is best expressed in terms of porosity + clay, as a % of bulk volume.

45 . A) Gen. Cat.--Clay behavior; basalt alteration

B) Cann, J. R., 1970, Rb, Sr, Y, Zr, and Nb in some ocean floor basaltic rocks: Earth and Planetary Science Letters, v. 10, p. 7-11.

C) Purpose: to find correlations in the abundance patterns of Rb, Sr, Y, Zr, and Nb in a variety of ocean basalt samples, including ocean floor weathered basalts.

Methods: X-ray florescent techniques, analysis was done on a wide variety of basalt types including fresh, weathered and metamorphosed samples.

Results: Rb, K, and to a lesser extent Sr are affected by ocean floor weathering while Y, Zr, Nb and Ti seem to be unaffected even by severe secondary processes.

46 . A) Gen. Cat.--Behavior of clay minerals (bedded salt)

B) Lerman, A.; Weiler, R., 1970, Diffusion and accumulation of chloride and sodium in Lake Ontario sediment: Earth and Planetary Science Letters, v. 10, p. 150-156.

C) Purpose: to determine cause and mechanism of Na^+ and Cl^- concentrations in Lake Ontario sediments.

Methods: concentrations of Na^+ and Cl^- were analyzed from 4 cores (Na^+ by flame emission photometry, Cl^- colorimetrically by mercury thiocyanate method on the Technicon Auto Analyzer). The resulting concentrations were fit into diffusion models to explain deposition mechanisms.

Results: increase of Na^+ and Cl^- through the century in the lake waters is due to rising inflow of industrial, agricultural and mining wastes into the lake. This is the cause of transfer of Na^+ and Cl^- to the sediments from this water. The distribution of these two elements fits mathematical models for diffusion and is thought to be the mechanism of transfer.

47 . A) Gen. Cat.--Clay behavior; bedded salts

B)Ben-Yaakov, S., 1971, Comments on "Diffusion and accumulation of chloride and sodium in Lake Ontario sediment": Earth and Planetary Science Letters, v. 13, p. 219.

C) Purpose: to point out discrepancies in the Lerman and Weiler paper in Earth and Planetary Science Letters, 1970, v. 10, p. 150-156.

Results: this paper states that Lerman and Weiler do not take into account the charges on the chloride and sodium ions and so their mathematical model does not hold.

B) Lerman, A.; Weiler, R., Diffusion of chloride and sodium in Lake Ontario sediment: 1. Ionic interaction, and 2. Accumulated amount of a reacting species.

C) Purpose: as a reply to Ben-Yaakov (above).

Results: Lerman and Weiler demonstrate mathematically that the ion charge effects are small in the diffusion model they proposed and so their ideas hold.

48 . A) Gen. Cat.--Clay mineral behavior

B) Copeland, R. A.; Frey, F. A.; Wones, D. R., 1971, Origin of clay minerals in a mid-atlantic ridge sediment: Earth and Planetary Science Letters , v. 10, p. 186-192.

C) Purpose: to differentiate the origins of fine and coarse grained clays found on the mid-ocean ridge.

Methods: chemical and mechanical means were used to separate size fractions and were then analyzed for Fe and REE by instrumental neutron activation. REE was limited to analysis of La, Ce, Eu,Dy, and Lu.

Results: the coarse grained clay (chlorite) was found to be derived from ridge greenstones while the fine grained clay (montmorillonite) is not (it is believed to be of continental origin). These conclusions were based on comparisons of Fe and REE patterns of the coarse and fine grained fractions with the Fe and REE patters of potential greenstone and continental sources.

49 . A) Gen. Cat.--Clay minerals

B) Huang, W. H.; Keller, W. D., 1971, Dissolution of clay minerals in dilute organic acids at room temperature: American Mineralogist, v. 56, no. 5 and 6, p. 1082-1095.

C) Purpose: to document quantitative measurements on the dissolution of clay minerals in several dilute organic acids in the laboratory at room temperature.

Methods: solubility studies.

Results: The total weight of clay minerals dissolved by strongly complexing organic acids exceeds that dissolved by distilled water by factors 5 to 75. Dissolved Si in strongly complexing acid solutions exceeded 2-35 times its concentration in distilled water; dissolved Al, 3-500 times. Aspartic acid dissolved Ca and Mg best. Clay minerals dissolve incongruently in distilled water, Sr preferentially to Al. In all acids used, Si incongruently exceeds Al dissolved from Arizona and Wyoming smectites, semi-plastic refractory clay, also for illites in salicylic acid, and Keokuk kaolinite in citric and tannic acid.

50. A) Gen. Cat.--Clay behavior

B) Jambar, J. L., 1971, Wall rock alteration: Candian Mineralogist, v. 11, p. 272-304.

C) Purpose: this is part of a study found in the same volume of the silver-arsenide deposits of the cobalt-Gowganda Region, Ontario.

Methods: chemical analyses and specific gravities were made of the wall rock alteration zones and unaffected zones.

Results: mineral composition is given for the alteration products as well as the original rocks. Temperature gradients are discussed (from ore vein outward) as well as the sequence of alteration in time and space.

51. A) Gen. Cat.--clay minerals, montmorillonite

B) Quakernaat, J., 1971, Octitic montmorillonite with exceptionally small net layer charge: Lithos, v. 4, p. 131-136.

C) Purpose: to present preliminary data of a montmorillonite with an exeptionally small net layer charge.

Methods: XRD, chemical analysis.

Results: this montmorillonite was derived from altered Tertiary pyroclastics in Italy. This clay mineral shows an 18 Å first order basal reflection if potassium saturated and glycerol solvated.

52 . A) Gen. Cat.--Clay minerals, kaolinite

B) Bayliss, P.; Warne, S. St. J., 1972, Differential thermal analysis of siderite-kaolinite mixtures: American Mineralogist, v. 57, no. 1-6, p. 960-966.

C) Purpose: to determine the lower detection limit of siderite in mixtures with kaolinite.

Methods: differential thermal analysis.

Results: it is suggested that the two sets (artificial mixtures and natural samples) of DTA curves delineate and elucidate the problem of detecting siderite when present with kaolinite. They indicate at least a minimum siderite peak temperature range which may be expected and also establish the detection limit variations to be expected under different controlled furnace atmosphere conditions.

53. A) Gen. Cat.--Clay minerals, water

B) Kitagawa, Y., 1972, An aspect of the water in clay minerals: an application of nuclear magnetic resonance spectrometry to to clay mineralogy: American Mineralogist, v. 57, no. 1-6, p. 751-764.

C) Purpose: to discuss the properties of water in several clay minerals.

Methods: nuclear magnetic resonance spectrometry.

Results: the energy levels of water are clearly distinguished between absorbed water and structural hydroxyl groups in layer silicates such as kaolinite, halloysite, and montmorillonite, but such differentiation of water in zeolite and allophane is very difficult. Especially in allophane, this is difficult because its atomic structure is as yet not clearly understood. The results of proton-exchange reactions and substitution of hydroxyl groups by fluoride suggest that all hydroxyl groups in allophane are exposed on the surface.

54. A) Gen. Cat.--Clay minerals, diffuse reflectance spectra

B) Lindberg, J. D.; Snyder, D. G., 1972, Diffuse reflectance spectra of several clay minerals: American Mineralogist, v. 57, no. 1-6, p. 485-493.

C) Purpose: to determine the character of the absorption spectra, in the shorter wavelength region, of several representative clay minerals.

Methods: diffuse reflectance spectroscopy.

Results: it is concluded that the major features of the near infrared absorption spectra of montmorillonite and kaolin clays are determined primarily by the water present in the clay structures. In addition, the spectra show evidence of strong absorption in the near ultraviolet and short wavelength visible region. This latter absorption is a general feature of all the clay samples investigated.

55. A) Gen. Cat.--Behavior of clays in geomedia

B) Olsen, H. W., 1972, Liquid movement through kaolinite under hydraulic, electric, and osmotic gradients: American Association of Petroleum Geologists Bulletin, v. 56, no. 10, p. 2022-2028.

C) Purpose: determine whether osmosis and electro-osmosis in clays are of sufficient magnitude, relative to hydraulic flow, that they should be considered in predictions of leakage through confining beds in isothermal groundwater systems.

Methods: clay sample is confined in a test cell and subjected to constant water flow. Relative magnitudes of hydraulic, osmotic, and electro-osmotic conductivities were all measured in this apparatus.

Results: hydraulic conductivity decreases with consolidation (i.e., "depth"). Osmotic conductivity/hydraulic conductivity increases with consolidation. Electro-osmotic conductivity/hydraulic conductivity increases with consolidation. All 3 show rebound effects if pressure is decreased after consolidation (same trends as above but gentler slopes).

Overall, osmotic and electro-osmotic conductivity are of increasing importance (relative to hydraulic conductivity) as depth increases, and, at depths of 10,000 ft., osmotic and electro-osmotic conductivity should be of sufficient magnitude to offset hydraulic conductivity.

56 . A) Gen. Cat.—Behavior of clays in geomedia

B) Coplen, T. B.; Hanshaw, B. B., 1973, Ultrafiltration by a compacted clay membrane - I. Oxygen and hydrogen isotopic fractionation: Geochimica et Cosmochimica Acta, v. 37, no. 10, p. 2295-2310.

C) Purpose: investigate isotopic fractionation due to passage of water through a membrane.

Methods: mass spectrometry.

Results: ultrafiltrates of both distilled water and 0.01 N NaCl solution were depleted in D by 2.5‰ and O^{18} by 0.8‰. Adsorption is the probable cause of the fractionation, but molecular diffusion may play a role.

57 . A) Gen. Cat.--Clay minerals

B) Giese, R. F. Jr.; Datta, P., 1973, Hydroxyl orientation in kaolinite, dickite, and nacrite: American Mineralogist, v. 58, no. 5 and 6, p. 471-479.

C) Purpose: to determine the orientations of the hydroxyl groups in the minerals kaolinite, dickite, and nacrite.

Methods: infrared absorption spectrometry.

Results: under the assumptions of full ionic charges, O-H distance of 0.97 Å, and the correctness of the crystal structures of kaolinite, dickite, and nacrite, it is possible to arrive at models for the hydroxyl orientations in these minerals by an iterative method of minimizing the electrostatic energy.

58 . A) Gen. Cat.--Behavior of clays in geomedia

B) Hanshaw, B. B.; Coplen, T. B., 1973, Ultrafiltration by a compacted clay membrane - II. Sodium ion exclusion at various ionic strengths: Geochimica et Cosmochimica Acta, v. 37, no. 10, p. 2311-2327.

C) Purpose: ascertain the effects of filtration on an electrolyte solution.

Methods: chemical methods.

Results: ultrafiltrate showed depletion of Na^+, due to ion exclusion by the clay. Electrical environment of the clay pores is dependent on pressure. Use of the Donnan membrane equilibrium concept and Teorell-Meyer-Siever theory allows development of a theory that explains the extent of ultrafiltration for solutions of various concentrations. Theory and lab results are in good agreement.

59 . A) Gen. Cat.--Behavior of clays in geomedia

B) Hiltabrand, R. R.; Ferrel, R. E.; Billings, G. K., 1973, Experimental diagenesis of Gulf Coast argillaceous sediment: American Association of Petroleum Geologists Bulletin, v. 57, no. 2, p. 338-348.

C) Purpose: report experimental data on the diagenesis of sediments and compare these with field information.

Methods: AAS, XRF.

Results: concentrations of Na+, K+, and Ca^{2+} in solution increased, while those of Mg^{2+} and SO_4^{2-} decreased during diagenesis. SiO_2 concentration approached equilibrium with quartz. Chamosite and illite were formed, while feldspar, kaolinite, and montmorillonite were destroyed. Data indicate that modern shale compositions are the result of diagenesis and not deposition.

60 A) Gen. Cat.—Clay minerals, montmorillonite

B) Tettenhorst, R.; Roberson, H. E., 1973, X-ray diffraction aspects of montmorillonites: American Mineralogist, v. 58, no. 1 and 2, p. 73-80.

C) Purpose: to determine if a relationship existed between particle thickness and basal X-ray spacings for montmorillonites, and to provide an overall view of the group which might suggest future lines of investigation.

Methods: XRD.

Results: theoretical analyses were made of the extent of irrationality of the basal orders of diffraction as a function of particle thinness and layer structure factor. The overall agreement of the experimental and theoretical data was not impressive. The apparent lack of agreement was partially due to the chemical variations among the clays and may reflect individual differences which were not accounted for in the theoretical computations, e.g., size distribution or interstratification.

61 . A) Gen. Cat.--Clay behavior

B) Wood, W. W., 1973, Rapid reaction rates between water and a calcareous clay as observed by specific-ion electrodes: Journal of Research of the USGS, v. 1, no. 2, p. 237-241.

C) Purpose: to observe reactions between water and calcareous clay.

Methods: specific-ion electrodes simultaneously determine activity changes of calcium, hydrogen, sodium, fluoride, and divalent ions when mixed layer, calcium rich, illite-montmorillonite clay, quartz, sand, and calcium carbonate were added to natural Canadian River water (plus a second run in distilled water).

Results: Ca and Mg were displaced from the clay by the Na. The displaced Ca then precipitated as $CaCO_3$ and the Mg stayed in solution. Fluoride entered into both rapid and long term reaction. pH decreased rapidly.

62 . A) Gen. Cat.--Clay minerals, stability

B) Huang, W. H., 1974, Stabilities of kaolinite and halloysite in relation to weathering of feldspars and nepheline in aqueous solution: American Mineralogist, v. 59, no. 3 and 4, p. 365-371.

C) Purpose: to interpret, through thermodynamic and kinetic relationships 1) the stabilities of kaolinite and halloysite formed by weathering of non-layer silicates, and 2) the relative abundances of these two minerals through geologic time.

Methods: Thermodynamic analyses

Results: newly designed stability diagrams, which consider Al as a mobile, reactive component (including hydrated Al^{3+}, $Al(OH)^{2+}$, $Al_2(OH)^{4+}_2$, $Al(OH)^+_2$, and $Al(OH)^-_4$ species) as well as parameters Na^+, K^+, H^+, and H_4SiO_4, show that in average river water halloysite and kaolinite are stable with respect to K-feldspar, albite, and nepheline. By contrast, in present sea water, kaolinite alone is stable in a system containing kaolins plus K-feldspar or albite, but both halloysite and kaolinite are stable in a system of kaolins and nepheline.

63 . A) Gen. Cat.--Clay minerals

B) Lindberg, J. D.; Smith, M. S., 1974, Visible and near infrared absorption coefficients of kaolinite and related clays: American Mineralogist, v. 59, no. 3 and 4, p. 274-279.

C) Purpose: to provide a quantitative estimate of the absorption coefficient of kaolinite clays by application of a method based on the Kubelka-Munk theory of diffuse reflectance.

Methods: diffuse reflectance spectrography, XRD.

Results: estimates of the Kubelka-Munk absorption coefficient, a quantity closely related to the Bouger-Lambert absorption coefficient, for several kaolin clays in the visible and near-infrared spectral region indicate that the absorption coefficient of these clays in atmospheric dust can be very low, on the order of 1 cm^{-1} in regions where absorption bands do not occur.

64 . A) Gen. Cat.--Behavior of clays in geomedia

B) Webb, J. E., 1974, Relation of oil migration to secondary clay cementation, Cretaceous sandstones, Wyoming: American Association of Petroleum Geologists Bulletin, v. 58, no. 11, p. 2245-2249.

C) Purpose: determine the effect of clay matrix on reservoir capabilities of sandstones.

Methods: sieving, petrography, SEM.

Results: clays are authigenic. Precipitation of kaolinite was the result of a drop in pH and/or a change in the composition of formation waters. This assumes alkaline formation water before kaolinite deposition. Kaolinite deposition occurred after oil migration into the sand bodies.

65. A) Gen. Cat.--Behavior of clays in geomedia

B) Bischoff, J. L.; Clancy, J. J.; Booth, J. S., 1975, Magnesium removal in reducing marine sediments by cation exchange: Geochimica et Cosmochimica Acta, v. 39, no. 5, p. 559-568.

C) Purpose: examine whether the CEC of clay sediments increases with depth.

Methods: AAS, CEC analyses, gamma-ray detection.

Results: exchange capacities increase under highly reducing conditions and result in removal of magnesium from seawater. However, the magnesium may actually be removed by fixation in clay lattices, and not by exchange.

66 . A) Gen. Cat.--Clay minerals

B) Hurst, V. J.; Bósio, N. J., 1975, Rio Capim kaolin deposits, Brazil: Economic Geology, v. 70, no. 5, p. 990-992.

C) Purpose: to describe the Rio Capim kaolin deposits and their implications for exploration.

Methods: chemical analyses, petrography, XRD.

Results: the Rio Capim kaolin formed as a secondary mineral in an old lateritic weathering profile. This implies 1) that the kaolin deposits might be quite extensive, 2) that higher alumina clays and even bauxites might be found rather than kaolin at some places, because the same processes that yield kaolin would with more intensive weathering yield bauxite, 3) that prospecting can best be guided by a map of this older zone of weathering.

66 . A) Gen. Cat.--Clay mineral behavior

B) Lerman, A.; Machenzie, F. T., 1975, Rates of dissolution of aluminosilicates in seawater: Earth and Planetary Science Letters, v. 25, p. 82-88.

C) Purpose: to study the dissolution of silica from twelve common aluminosilicates and quartz in seawater.

Methods: samples of clays, zeolites and quartz were placed in filtered seawater of known silica composition. Minerals were less than 62 micrometers and aliquots withdrawn for analysis were filtered through a .45 micrometer filter. Silica concentrations were determined to ±5% precision. Samples were measured over an 8½ year period.

Results: for most minerals, dissolution is described as a 1st order reaction in which dissolved silica approaches from undersaturation steady concentration values with time. Characteristic reaction rate constants are of the order of $10^{-7} sec^{-1}$. One zeolite clinoptilolite shows different behavior: SiO_2 concentration in solution reaches a high value within a year, followed by decline to a lower value, suggesting precipitation of another phase. A math solution is given for a kinetic equation combining the parabolic-rate and 1st order rate processes. The parabolic-rate dissolution process cannot be detected in most reactions and so are not included in the kinetic equations. The experimental rates of dissolution are comparable to dissolution rates in ocean sediments near the sediment/ocean interface. Deeper sediments,however,show slower rates.

67 . A) Gen. Cat.--Clay

B) Smalley, I. J.; Bentley, S. P., 1975, The St. Jean Vianney quickclay: Bulletin Volcanologique, v. 13, p. 364-369.

C) Purpose: to study extremely sensitive clays from St. Jean Vianney, Quebec.

Methods: thermogravimetry, x-ray diffraction and x-ray fluorescence spectroscopy.

Results: 4 major thermal events were detected by thermogravimetry, and mineral content of the clay is described.

68 . A) Gen. Cat.-- Clay minerals, growth spirals, kaolin

B) Sunagawa, I.; Koshino, Y.,1975, Growth spirals on kaolin group minerals: American Mineralogist, v. 60, no. 5 and 6, p. 407-412.

C) Purpose : to apply the decoration technique of electron microscopy to kaolinite, dickite, and nacrite from four hydrothermal metasomatic deposits in Japan.

Methods: electron microscope.

Results: growth spirals of mono-molecular step heights are observed on their basal planes, showing that they formed by spiral growth mechanisms from solution phases of low supersaturation.

69 . A) Gen. Cat.--Behavior of clay minerals in geomedia

B) Churchman, G. J.; Jackson, M. L., 1976, Reaction of montmorillonite with acid aqueous solutions: solute activity control by a secondary phase: Geochimica et Cosmochimica Acta, v. 40, no. 10, p. 1251-1259.

C) Purpose: assess the assumption of equilibrium underlying solubility determinations of thermodynamic properties of montmorillonite.

Methods: chemical analyses, AAS, colorimetry, XRD.

Results: the calculated equilibrium constant for the solubility of montmorillonite varied with pH in the pH range 1.5 - 4.2 and was therefore not in a unique state of equilibrium. Lack of congruent dissolution and interdependency among concentration of ions in solution indicate solute activity control by a secondary solid phase. Silicon- and alumina-rich solid phases were detected.

70. A) Gen. Cat.--Behavior of clays in geomedia or Alteration studies

B) Foscolos, A. E.; Powell, T. G.; Gunther, P. R., 1976, The use of clay minerals and inorganic and organic geochemical indicators for evaluating the degree of diagenesis and oil generating potential of shales: Geochimica et Cosmochimica Acta, v. 40, no. 8, p. 953-966.

C) Purpose: establish a relationship between clay minerals and organic matter during diagenesis.

Methods: gas chromatography, XRD,.chemical analyses, uitrinite reflectance measurements.

Results: The following model of diagenesis is proposed:

Early diagenesis - loss of pore water from shales

Middle diagenesis - first and second stages of clay dehydration occur; formation of bituminous coal.

Late diagenesis - production of dry gas.

71. A) Gen. Cat.--Clay minerals, allophane

B) Henmi, T.; Wada, K., 1976, Morphology and composition of allophane: American Mineralogist, v. 61, no. 5 and 6, p. 379-390.

C) Purpose: to obtain information about morphology and composition of structure units which may be present in allophane, as compared with those of the stucture unit of imogolite.

Methods: electron microprobe, chemical analyses, infrared spectroscopy, XRF spectroscopy.

Results: high-resolution electron microscopy showed that allophane in the samples studied consists of morphologically similar particles. This suggests that certain allophanes must have definite structural arrangements and therefore cannot be considered "amorphous."

72 . A) Gen. Cat.--Behavior of clays in geomedia _or_ Behavior of actinides in geomedia _or_ Alteration studies

B) Krishnaswami, S., 1976, Authigenic transition elements in Pacific pelagic clays: Geochimica et Cosmochimica Acta, v. 40, no. 4, p. 425-434.

C) _Purpose_: estimate authigenic deposition rates of transition elements.

Methods: ^{230}Th exchange method, INAA, AAS, colorimetry, alpha spectrometry.

Results: the majority of the Mn, Co, Ni, and Cu is authigenic; whereas over 90% of the Sc, Ti, Fe, La, Th, and U is detrital. Mn, Co, and Ni are accumulating at 2-10 times their detrital supply; the opposite is true for U and Cu.

73 . A) Gen. Cat.--Clay minerals

B) Summers, K. V., 1976, The clay component of the Columbia River palagonites: American Mineralogist, v. 61, no. 5 and 6, p. 492-494.

C) Purpose: to determine the mineralogy of the clay component.

Methods: X-ray analysis, differential thermal analysis, petrography.

Results: apparently the predominant clay mineral in Columbia River Group basalt palagonite is nontronite. Other areas of palagonite may have another smectite as the predominant clay component, such as montmorillonite in the palagonite tuffs of the Honolulu Group in Hawaii and saponite in tuffs of Palagonia, Sicily.

74 . A) Gen. Cat.--Clay, basic igneous rock alteration

B) Amiri-Garroussi, K., 1977, Origin of montmorillonite in the early Jurassic shales of N.W. Scotland: Geology Magazine, v. 114, p. 281-290.

C) Purpose: to describe the occurrence and origin of montmorillonite in N.W. Scotland.

Methods: chemical analysis (x-ray diffraction)

Results: this unusual occurrence of montmorillonite for the area (Lower Broadford Beds) is argued to have been derived by weathering of basic igneous rocks.

75. A) Gen. Cat.--Behavior of clay minerals in geomedia and Sorption studies

B) Dayal, R.; 1977, Kinetics of silica sorption and clay dissolution reactions at 1 and 670 atm.: Geochimica et Cosmochimica Acta, v. 41, no. 1, p. 135-141.

C) Purpose: study the effects of pressure on clay-seawater reactions.

Methods: SEM, AAS.

Results: diffusion is the rate controlling process in both clay dissolution and reconstitution. Rate constants are on the order of 10^{-13} moles/sec$^{\frac{1}{2}}$cm^2. Diffusion coefficient for silicic acid and silica sorption reactions lies within the range 10^{-13}-10^{-17} cm^2/sec. Effects of pressure were insignificant.

76 . A) Gen. Cat.--Behavior of clay minerals in geomedia

B) Sayles, F. L.; Mangelsdorf, P. C., Jr., 1977, The equilibration of clay minerals with seawater: exchange reactions: Geochimica et Cosmochimica Acta, v. 41, no. 7, p. 951-960.

C) <u>Purpose</u>: report data for equilibrium cation exchange composition of clays in water.

<u>Methods</u>: AA, difference chromatography, chemical analyses.

<u>Results</u>: rinsing procedures of earlier experiments have grossly shifted the exchange equilibria away from true seawater conditions. These data (no rinsing involved) show that exchangeable Na^+ $\geq$ exchangeable Mg^{2+} on clays in exchange equilibrium with seawater. Fluvial clays tend to give up Ca^{2+} for Na^+ when reacted with seawater.

77. A) Gen. Cat.--Clay

B) Bentley, S. P.; Smalley, I. J., 1978, Mineralogy of sensitive clays from Quebec: Canadian Mineralogist, v. 16, p. 103-112.

C) Purpose: to determine the mineral content of sensitive clays (quick clay) from Quebec.

Methods: collected samples were analyzed by x-ray diffraction, x-ray fluorescence, thermogravimetry and selective dissolution.

Results: mineral contents are described. The mineralogical results suggest that the interaction of primary mineral particles and amorphous matter plays an important role in the formation of sensitive clays.

78 . A) Gen. Cat.—Clay minerals

B) Eberl, D.; Whitney, G.; Kyoury, H., 1978, Hydrothermal reactivity of smectite: American Mineralogist, v. 63, no. 3 and 4, p. 401-409.

C) Purpose: to explore the effects of chemical composition, temperature, and pressure on the hydrothermal alteration of smectite to mixed-layer clay.

Methods: experimental petrology, XRD.

Results: smectite is not necessarily a low-temperature mineral. Trioctahedral smectite is stable at high temperatures, whereas dioctahedral smectite will react. The hydrothermal stability of dioctahedral smectite can be increased both by saturation with interlayer cations of hydration energy greater than potassium, and by increased water pressure.

79. A) Gen. Cat.--Behavior of clays in geomedia

B) Eberl, D., 1978, The reaction of montmorillonite to mixed-layer clay: the effect of interlayer alkali and alkaline earth cations: Geochimica et Cosmochimica Acta, v. 42, no. 1, p. 1-7.

C) Purpose: explore the swelling mechanism in 2:1 clays at high T's (300 - 400°C).

Methods: XRD, AAS.

Results: Reaction rate for the alkaline earth clays was directly related to interlayer hydration energy. Clays saturated with monovalent cations gradually transformed smectite layers into collapsed layers, whereas those with divalent cations go directly from smectite to a rectorite-like phase. Some interlayer cations seem to be strongly hydrated (especially Li).

80 . A) Gen. Cat.--Clay behavior

B) Force, L. M.; Moncure, G. K., 1978, Origin of two clay-mineral facies of the Potomac group (Cretaceous) in the middle Atlantic states: Journal of Research of the USGS, v. 6, no. 2, p . 208-214.

C) Purpose: to determine the origin of two clays on the Atlantic coast and their relation to sedimentary facies and groundwater ion-concentration patterns.

Methods: chemical analysis of groundwater, x-ray diffractometer to identify clay, petrography.

Results: kaolinite and illite were probably derived from intense acid weathering of metamorphic and granitic rocks and deposited in a well drained basin. Montmorillonite was probably produced by deep weathering of a mainly granite source. Poor drainage and alkaline surface- and ground water conditions accompanied the production, transportation, deposition and burial of the montmorillonite. Kaolinization is taking place in part of the montmorillonite facies now.

81. A) Gen. Cat.--Behavior of clays in geomedia

B) Powell, T. G.; Foscolos, A. E.; Gunther, P. R.; Snowdon, L. R., 1978, Diagenesis of organic matter and fine clay minerals: a comparative study: Geochimica et Cosmochimica Acta, v. 42, no. 8, p. 1181-1197.

C) Purpose: assess the validity of correlating inorganic with organic geochemical data to arrive at a diagenetic scheme.

Methods: petrography, XRD, gas chromatography.

Results: thermal diagenesis transforms smectite-vermiculite-illite to smectite-vermiculite-illite-chlorite, by incorporation of amorphous inorganic material. Dehydration is accompanied by sorption of K^+ and substitution of Al^{3+} for Si^{4+} in the clay lattice. Vermiculite is an intermediate step in the transformation of smectite to illite. Clay transformations do not coincide with hydrocarbon generation and the role of clays in oil migration is still open to question.

82 . A) Gen. Cat.--Clay, basalt alteration

B) Sayfried, W. E., Jr.; Shanks, W. C., III; Dibble, W. E., Jr., 1978, Clay mineral formation in DSDP Leg 34 basalt: Earth and Planetary Science Letters, v.41, p. 265-276.

C) Purpose: to determine what reactions produce observed alteration mineralogy in these basalts and if the reactions account for concentration gradients in interstitial waters from sediments overlying the basalts. Also if the reactions have significant effect on elemental fluxes in the oceans and how does this diagenesis differ from open seafloor weathering of basalts.

Methods: by isotopically, mineralogically and chemically characterizing two clay minerals which dominate vein alteration within the 10.5 m of basalt cored during DSDP Leg 34 at Site 321 in the Nazca plate. Analysis was done by x-ray diffraction and adsorption spectrophotometry. The two minerals are a blue green smectite (iron rich saponite) and green mica (celadonite).

Results : oxygen isotope analysis of these clays and associated calcite, indicate a formation temperature of $< 25^\circ C$. Celadonite contains appreciable Fe_2O_3, K_2O and SiO_2, intermediate MgO, and very little Al_2O_3. Celadonite is commonly associated with goethite and hematite, which suggests that it formed by precipitation within a dominantly oxygenated environment of components leashed from basalt and provided by seawater. A mass balance estimate indicates that celadonite formation can remove no more than 15% of the K annually transported to the oceans and rivers. In contrast, iron-rich saponite containing significant Al_2O_3 appears to have precipitated from a non-oxidizing, 82 . . (cont.)

distinctly alkaline fluid containing a high Na/K ratio relative to unmodified seawater. Seawater-basalt interaction at low temperatures, resulting in formation of celadonite and smectite may explain chemical gradients observed in interstitial waters of sediments overlying basalts.

83. A) Gen. Cat.-- Behavior of clays in geomedia or Sorption studies

B) Spoljaric, N.; Crawford, W. A., 1978, Glauconitic greensand: a possible filter of heavy metal cations from polluted water: Environmental Geology, v. 2, no. 4, p. 215-221.

C) Purpose: examine the efficiency of glauconitic greensand as a heavy metal filter.

Methods: AAS, wet chemical techniques.

Results: the ability of glauconitic greensand (75-80% glauconite) to retain cations is partially controlled by pH. Under acidic conditions, Fe, Mn, K, and some Se, Si, Al, and Na will be removed. Ag, Mg, and some Na are removed from basic solutions, but Al, Ca, and Fe may be released into solution. Greensand is a useful filter for Pb, Cu, Co, Cd, Cr, Ni, Zn, Ag, and Hg regardless of pH.

84 . A) Gen. Cat.--Clay Minerals

B) Chernosky, J. V., Jr., and Autio, L. K., 1979, The stability of anthophyllite in the presence of quartz: American Mineralogist, v. 64, no. 3 and 4, p. 294-303.

C) Purpose: to experimentally bracket the dehydration reactions anthophyllite = enstatite + quartz + fluid (1) and talc = anthophyllite + quartz + fluid (2).

Methods: experimental petrology, petrography, XRD.

Results: smooth curves drawn through the bracketing data for reactions (1) and (2) pass through the coordinates 2 kbar, 770°; 1.5 kbar, 755°; 1 kbar, 730°; 0.5 kbar, 680° and 3 kbar, 738°; 2 kbar, 711°; 1.5 kbar, 697°;1 kbar, 678°; .5 kbar, 655°C, respectively.

85 . A) Gen. Cat.--Behavior of clays in geomedia

B) Dypvik, H.; Vollset, J., 1979, Petrology and diagenesis of Jurassic sandstones from Norwegian Danish Basin, North Sea: American Association of Petroleum Geologists Bulletin, v. 63, no. 2, p. 182-193.

C) Purpose: provide information on porosity and permeability of these rocks.

Methods: petrography, SEM, XRD.

Results: silica was earliest formed cement, followed by kaolinite, which precipitated from silica-and aluminum-enriched solutions. Sparry calcite formed 3rd cement, followed by kaolinitization of detrital K-spar by meteoric water, effectively destroying porosity and preventing chlorite, biotite, and plagioclase from being altered. Note that the illite/kaolinite ratio may thus not be indicative of the detrital amounts of these clays.

86 . A) Gen. Cat.--Clay; alteration of basalt

B) Krishnaswami, S.; Macdougall, J. D.; Finkel, R. C.; Carlson, J., 1979, Isotopic evidence for uranium exchange during low-temperature alteration of oceanic basalt: Earth and Planetary Science Letters, v. 42, p..27-34.

C) Purpose: to show evidence for uranium exchange during low-temperature alteration of oceanic basalt.

Methods: isotope ratios were determined,alpha particle spectrometry.

Results: U concentration and $^{234}U/^{238}U$ ratio in basalts that have been altered by low temperature seafloor processes indicate that uranium uptake is pervasive, but the various phases involved act differently with respect to this process.

87. A) Gen. Cat.--Behavior of clays in geomedia or Sorption studies

B) Spoljaric, N.; Crawford, W. A., 1979, Removal of contaminants from landfill leachates by filtration through glauconitic greensands: Environmental Geology, v. 2, no. 6, p. 359-363.

C) Purpose: determine the capacity of greensand, ± charcoal, to purge heavy metal cations from leachate.

Methods: AAS, wet chemical techniques

Results: charcoal, either with greensand or alone, increases the heavy metal content. Greensand removes many heavy metals effectively, especially under low flow rates. Flushing charged greensand does not result in significant release of cations back into solution.

88 . A) Gen. Cat.--Clay

B) Brey, G.; Schminche, H. V., 1980, Origin and diagenesis of the Roque Nublo Breccia, Gran Canaria (Canary Islands): Petrology of Roque Nublo Volcanics, II: Bulletin Volcanologique, v. 43, no. 1, p. 15-34.

C) Purpose: study of the Nublo Breccia.

Methods: petrography, chemical microprobe.

Results: breccia is altered to palagonite and partly replaced by clay minerals. The mechanisms are discussed.

89. A) Gen. Cat.--Behavior of clays in geomedia

B) Lahann, R. W.; Roberson, H. E., 1980, Dissolution of silica from montmorillonite: effect of solution chemistry: Geochimica et Cosmochimica Acta, v. 44, no. 12, p. 1937-1943.

C) Purpose: determine the influence of solution chemistry on the rate of silica removal from smectite.

Methods: AAS.

Results: silica removal rate increased with temperature, decreased with time, and could initially be approximated by a parabolic rate law. Increasing K^+ increased the rate of silica removal, while increasing Ca^{2+}, Mg^{2+}, and Na^+ had the opposite effect. Activation energies range from 5-10 kcal/mole and suggest that the rate determing step for silica removal is transport through a hydrated, expanded interlayer space.

90 . A) Gen. Cat.--Geothermal clays

B) Marumo, K.; Nagasawa, K.; Kuroda, Y., 1980, Mineralogy and hydrogen isotope geochemistry of clay minerals in the Ohnuma Geothermal Area, Northeastern Japan: Earth and Planetary Science Letters, v. 47, p. 255-262.

C) Purpose: to study mineralogy and hydrogen isotopes in the Ohnuma geothermal area (Japan) clays.

Methods: x-ray diffraction for clay mineralogy, mass spectrometer for hydrogen isotopes.

Results: smectite, kaolinite, dickite, sericite, and chlorite were formed by hydrothermal alteration of Miocene rocks. Chemical equilibrium is assumed. The H isotope composition (D/H) of the clay is lighter than that of the geothermal and local meteoric waters by 20-40%. The hydrogen isotopic fractionation factors (alpha mineral-water) are as follows: 0.972-0.985 for kaolinite and dickite, 0.973-0.977 for sericite and 0.954-0.987 for chlorite. In the temperature range 100-250°C, the H isotope fractionation factors between these minerals and water are not sensitive to the temperature. Alpha chlorite water depends on the kind of octahedrally coordinated cations which lie close to the hydroxyl groups. It becomes large with an increase of Mg content to chlorite.

91 . A) Gen. Cat.--Clay minerals

B) Bauer, J. F.; Sclar, C. B., 1981, The "10 Å phase" in the system $MgO-SiO_2-H_2O$: American Mineralogist, v. 66, no. 5 and 6, p. 576-585.

C) Purpose: to report the results of a study of the composition and structure of the 10Å phase.

Methods: XRD, infrared absorption spectroscopy, thermal analysis.

Results: the 10Å phase is a unique high-pressure phyllosilicate phase in the ternary system $MgO-SiO_2-H_2O$. It has a specific fixed composition independent of the temperature and pressure of synthesis which may be expressed stoichiometrically as $3MgO:4SiO_2:2H_2O$.

92. A) Gen. Cat.--Clay

B) Birgiil, O., 1981, Scandium-iron correlation in clay minerals: Earth and Planetary Science Letters, v. 55, p. 450-452.

C) Purpose: to find correlation between scandium and iron in clays.

Methods: samples of various clay minerals were collected from Turkey and Canada and anlyzed using neutron activation.

Results: the degree of correlation is determined by the type of clay minerals present.

93 . A) Gen. Cat.--Clay minerals

B) Loughnan, F. C.; Roberts, F. I., 1981, The natural conversion of ordered kaolinite to halloysite (10 Å) at Burning Mountain near Wingen, New South Wales: American Mineralogist, v. 66, no. 9 and 10, p. 997-1005.

C) Purpose: to study the various intermediate phases in the reaction sequence ordered kaolinite -- metakaolin -- halloysite (10Å), in an area where burning coal seams have considerably altered the kaolinite.

Methods: petrography, chemical analyses, XRD, differential thermal analyses, infrared absorption studies.

Results: The following conclusions were drawn:

1) The halloysite (10Å) developed from ordered kaolinite of the clay rocks by two separate mechanisms; 1) That constituting the thick, persistant clay zone beneath the burned coal seam evolved through the initial conversion of the kaolinite to metakaolin, by heat from combustion of the coal, and the subsequent rehydroxylation of the metakaolin through reaction with groundwaters, and 2) the halloysite (10Å) forming the thin veins, on the other hand, is probably the product of solfataric activity.

2) The temperatures attained in the halloysite-rich clay zone ranged from a little above 400°C at the base to about 950°C immediately below the burning zone. Above the burnt seam they were considerably higher, and probably reached 1750°C in places.

94 . (cont.)

3) The reason for the development of halloysite (10Å) instead of kaolinite as the rehydroxylated phase in the clay zone is not clear, since all attempts to synthesize halloysite (10Å) from the naturally occurring metakaolin by hydrothermal means have proven unsuccessful. From the results, however, it would appear that the upper temperature limit for development of halloysite does not lie much above ambient conditions.

4) As far as can be determined, this is the first record of naturally occurring metakaolin.

95 . A) Gen. Cat.--Behavior of clay minerals in geomedia

B) Roberson, H. E.; Lahann, R. W., 1981, Smectite to illite conversion rates: effects of solution chemistry: Clays and Clay Minerals, v. 29, no. 2, p. 129-135.

C) Purpose: determine effect of Na^+, Ca^{2+}, and Mg^{2+} on the kinetics of the reaction smectite + K^+ → illite/smectite + SiO_2.

Methods: XRD, AAS, spectrophotometry.

Results: reaction rate and rate of ordering of illite/smectite (I/S) was inhibited by the presence of Na, Ca^{2+} or Mg^{2+}. The inhibitory strength of these 3 cations was in the ratio Na:Ca:Mg = 1:10:30. The reaction smectite → I/S appears to proceed by solid state transformation.

96. A) Gen. Cat.--Behavior of clay minerals in geomedia

B) Benson, L. V., 1982, A tabulation and evaluation of ion exchange data on smectites: Environmental Geology, v. 4, no. 1, p. 23-29.

C) Purpose: review ion exchange equilibrium constants for smectite.

Methods: literature review.

Results: equilbrium constants for monovalent-monovalent and monovalent-divalent exchange for the same reaction on the same type of smectite can differ by a factor of ten. Data indicate that this is due to differences in charge density and effective field strengths of the smectites, which are related to the amount and type of substitution in intercrystalline octahedral and tetrahedral sites. Cation exchange selectivity appears to be strongly influenced by temperature.

97 . A) Gen. Cat.--Behavior of clays in geomedia

B) Kreit, J. F.; Shainberg, I.; Herbillon, A. J., 1982, Hydrolysis and decomposition of hectorite in dilute salt solutions: Clays and Clay Minerals, v. 30, no. 3, p. 223-231.

C) <u>Purpose</u>: study the chemical stability of hectorite in dilute salt solutions.

<u>Methods</u>: AAS, flame photometry, colorimetry, wet chemical methods.

<u>Results</u>: rate of hydrolysis of hectorite in suspension decreases with an increase in salt concentration, or with an increase in the valency of the adsorbed cation (hydrolysis of Ca-hectorite was one sixth as fast as that of Na-hectorite). However, in suspensions of Al-hectorite saturated with Na, hydrolysis rates were not dependent on the elctrolyte concentrations. Hectorites saturated with structural cations (such as Mg and Li) are chemically more stable than those saturated with Ca or Na.

98 . A) Gen. Cat.--Clay, ash alteration

B) Smith, D. B.; Zielinski, R. A.; Rose, W. I., 1982, Leachability of uranium and other elements from freshly erupted volcanic ash: Journal of Volcanology and Geothermal Research, v. 13, p. 1-30.

C) Purpose: to test leachability of U and other elements from fresh volcanic ash.

Methods: ash samples are leached experimentally and soluble products are analyzed.

Results: glass dissolution is the dominant process in which uranium is initially mobilized along with Si, Li, and V. Gaseous transfer may be important in forming water soluble phases, adsorbed to ash surfaces enriched in Zn, Cu, Cd, Pb, B, F, Ba. Other leach mechanisms are discussed.

99. A) Gen. Cat.--Behavior of clay minerals in geomedia

B) Bish, D. L., 1984, Effects of exchangeable cation composition on the thermal expansion/contraction of clinoptilolite: Clays and Clay Minerals, v. 32, no. 6, p. 444-452.

C) Purpose: predict the effects of a thermal pulse on clinoptilolite bearing rocks.

Methods: XRD.

Results: unit cells of all samples decreased in volume as temperature increased from 20°C to 300°C. Na-saturated clinoptilolite experienced the greatest decrease (8.4%), while K-saturated experienced the least (1.6%). The greatest change occurred along the "b" axis, generally 80-90% of the total volume decrease. Volume reduction was due to water loss. Unit cell volumes of clinoptilolite in partially saturated rocks should not decrease significantly at temperatures less than 100°C.

100 . A) Gen. Cat.--Clay minerals

B) Blount, A. M.; Williams, D.; Jenkins, J.; Warner, B., 1983, Expandable lager silicates associated with the hydrothermal talc deposits of Murphy, North Carolina: Economic Geology, v. 78, no. 3, p. 486-497.

C) Purpose: 1) show that there is an alteration zone around the Murphy talc deposit similar in extent to the zone at the Winterboro talc deposits, 2) show that the alteration is defined by a zonal arrangement of layer silicates 3) and to relate this alteration to the origin of the talc deposit.

Methods: petrography, chemical analyses, O and C isotopes.

Results: marbles, limestones, and dolomites which show no visible alteration effects may show hydrothermal alteration haloes when the mineralogy of the insoluble residues is examined.

102 . A) Gen. Cat.--Behavior of clay minerals in geomedia

B) Bruce, Clemont H., 1984, Smectite dehydration - its relation to structural development and hydrocarbon accumulation in northern Gulf of Mexico basin: American Association of Petroleum Geologists Bulletin, v. 68, no. 6, p. 673-683.

C) <u>Purpose</u>: to assess the impact clay diagenesis has on hydrocarbon accumulation.

<u>Methods</u>: analysis of well log data (to ascertain geothermal gradients), XRD and chemical analysis of shales.

<u>Results</u>: conversion of smectite to illite in the mixed layer fraction with increasing temperature (increasing depth) resulting in loss of interlayer water from smectite into pore system of host shale.

Conversion T's: 105 - 138°C (in Texas) and 71 - 163°C (in Louisiana)

Smectite diagenesis is a principal mechanism for development of abnormal pore pressure in the Tertiary section of the U.S. Gulf Coast.

Thermal expansion of water, with generation of gas, may initiate microfracturing within overpressured sections during basin subsidence, facilitating hydrocarbon migration.

103. A) Gen. Cat.--Behavior of clays in geomedia

B) Curtis, C. D., 1983, Link between aluminum mobility and destruction of secondary porosity: American Association of Petroleum Geologists Bulletin, v. 67, no. 3, p. 380-383.

C) Purpose: establish an understanding of the chemical conditions under which minerals either dissolve or precipitate.

Methods: review of literature, construction of stability diagram (ΣAl vs. pH)

Results: kaolinite, rather than a cation rich clay, is stable at low pH. Kaolinite solubility increases rapidly at high or low pH. Calcite dissolution will increase pH, causing supersaturation with respect to kaol. "Al must be considered significantly mobile." At higher pH's, Al precipitates as kaol. Petrographic data supports simultaneous kaol. precipitation and carbonate dissolution.

104 . A) Gen. Cat.--Behavior of clays in geomedia

B) Fritz, S. J.; Marine, I. W., 1983, Experimental support for a predictive osmotic model of clay membranes: Geochimica et Cosmochimica Acta, v. 47, no. 8, p. 1515-1522.

C) Purpose: to test an osmotic efficiency model and determine whether osmosis is a viable mechanism for producing anomalously high fluid pressures in the subsurface. Methods: NaCl was passed through a bentonite clay in a hyperfiltration set-up. Results: a theoretical maximum osmotically induced hydraulic pressure generated across a clay or shale unit can be calculated solely from solution properties on either side of the membrane. Osmotic efficiency of bentonite can be high enough to induce hydraulic pressures in the subsurface. Maximum hydraulic pressures should be induced when a low porosity, high CEC unit separates solutions of moderate concentration.

105 . A) Gen. Cat.--Clay minerals

B) Koster van Groos, A. F.; Guggenheim, S., 1984, The effect of pressure on the dehydration reaction of interlayer water in Na-montmorillonite (SWy-1): American Mineralogist, v. 69, no. 9 and 10, p. 872-879.

C) Purpose: to report the effect of pressure on the interlayer dehydration of a Na-montmorillonite from Wyoming (American Clay Society Standard, SWy-1).

Methods: differential thermal analysis, XRD, SEM.

Results: it is concluded that hydrated Na-montmorillonite is stable under normal pressure and temperature distributions in sedimentary basins; in these basins dehydration must involve more complex chemical interactions with pore fluids. The large increase in the stability of a hydrated montmorillonite with a modest increase in pressure may have important bearing in its use in nuclear waste disposal.

106. A) Gen. Cat.--Behavior of clays in geomedia or Active and semidormant hydrothermal systems.

B) McMurtry, G. M.; Chung-Ho, W.; Yeh, H., 1983, Chemical and isotopic investigations into the origin of clay minerals from the Galapagos hydrothermal mounds field: Geochimica et Cosmochimica Acta, v. 47, no. 3, p. 475-489.

C) Purpose: apply δO^{18} geothermometry to hydrothermal deposits where temperature can be measured, and investigate the origin of smectites in surrounding sediments.

Methods: XRD, SEM, mass spectrometry.

Results: smectite in mounds themselves is an Al-poor nontronite; Fe-rich montmorillonite is the dominant smectite in surrounding pelagic ooze. This agrees with previous work here and on the East Pacific Rise. Both areas contain iron oxide and amorphous silica. δO^{18} suggest mound smectites have formed in the T range 25°-47°C. This relatively high T can be explained by a) complex hydrology in the mounds, b) variations in thermal history, of c) errors in use of δO^{18} geothermometer. Calculated T for formation of pelagic smectite is also relatively high, and could be due to b) or c) above, or from the addition of terrigineous montmorillonite.

107. A) Gen. Cat.--Behavior of clays in geomedia

B) Tsuzuki, Y.; Kawabe, I.,1983, Polymorphic transformations of kaolin minerals in aqueous solutions: Geochimica et Cosmochimica Acta, v. 47, no. 1, p. 59-66.

C) Purpose: study dissolution of kaolinite, halloysite, and allophane-like amorphous hydrous aluminosilicate.

Methods: SEM, TEM, XRD, infrared spectroscopy.

Results: polymorphic transformation occurs easily by dissolution of a metastable phase and precipitation of a more stable phase. Dissolution rate becomes more congruent as dissolution progresses (incongruent at first). Solutions reached equilibrium with hydrous alumina or aluminosilicate. Kaolinite stability was not reached during the experiment. Dissolution of halloysite results in a solution that is in equilibrium with kaolinite although halloysite is present, and kaolinite will precipitate. Dissolution of amorphous hydrous aluminosilicate results in precipitation of gibbsite; as this re-reacts with solution, halloysite precipitates.

108 . A) Gen. Cat.--Clay minerals

B) Yeskis, D.; Kaster Van Groos, A. F.; Guggenheim, S., 1985, The dehydroxylation of kaolinite: American Mineralogist, v. 70, no. 1 and 2, p. 159-164.

C) Purpose: to investigate the nature of the dehydroxylation of kaolinite.

Methods: high pressure differential thermal analysis.

Results: the dehydroxylation of kaolinite proceeds in a series of well-defined metastable reactions around an invariant point. The development of transitional phases in other clay systems similar to metakaolin (especially in smectite), suggests the likely presence of a meta-liquid phase in those systems as well.

CONTACT METAMORPHISM

1 . A) Gen. Cat.--Contact metamorphism

B) Zakariadze, G. S., 1961, Behavior of lithium and rubidium in contact metamorphism (illustrated by the Vakis-Dzhvari intrusive, Georgian SSR): Geochemistry, no. 7, p. 622-637.

C) Purpose: use Li and Rb to provide clues to the process of material exchange due to contact metamorphism.

Methods: petrography, flame photometry.

Results: Li is relatively immobile and no Li enrichment of the intruded rocks was detected. Rb behaves as a completely mobile component and the Rb content of the intrusive and intruded rocks near the contact is the same.

2 . A) Gen. Cat.--Contact metamorphism

B) Anderson, A.L., 1963, Contact syenitization in the Yellowjacket district, Lemhi County, Idaho: American Journal of Science, v. 261, no. 9, p. 826-838.

C) Purpose: discuss the contact metasomatism of a siliceous sediment in the Salmon River Mountains of Idaho.

Methods: petrography

Results: metasomatism was induced by alkalic fluids from differentiating magmas. These fluids, enriched in Na, K, and Ti, caused widespread formation of albite, and closer to the contact, formation of K-spar. Ti is fixed as sphene in the inner zone, as were some radioactive minerals (monazite and euxinite).

3 . A) Gen. Cat.--Contact metamorphism

B) Oppenheim, M. J., 1963, The Hefzi-Bah limestone-dolerite contacts, Israel Journal of Earth Sciences, v. 12, no. 2, p. 56-57.

C) Purpose: to describe the contacts between dolomitic limestone and dolerite from Hefzi-Bah, Mt. Gilboa.

Methods: petrography.

Results: the metamorphic effects are distinct in the lower and upper portions of the exposure. The immediate contact is obscured by hydrothermal alteration, the effect of which pass into the adjacent dolerite. This hydrothermal endogenous zone continues inwards with a diminution in degree, and no dolerite specimens have been found which can safely be considered to represent the original unaltered rock.

4 . A) Gen. Cat.--Contact metamorphism

B) Barker, F., 1964, Reaction between mafic magmas and pelitic schist, Cortlandt, New York: American Journal of Science, v. 262, no. 5, p. 614-634.

C) Purpose: analyze the controlling factors on the assemblages resulting from contact metamorphism in the Cortlandt complex.

Methods: petrography, use of published data.

Results: xenoliths of pelitic schist have reacted with mafic magmas to form Al and Fe-Mg hornfels and spinel emery. Compositions of hornfels vary according to the host rock (hornblende diorite, norite, norite/pyroxenite, peridotite). Schist lost SiO_2, H_2O, and K_2O during the reaction. Applying Korzhinskii's phase rule, Fe is an excess component (cpt); Al_2O_3, MgO, and SiO_2 are determining inert cpt's; H_2O, O_2, and Na_2O are perfectly mobile cpt's; and TiO_2, K_2O, and CaO are accessory inert cpt's.

5 . A) Gen. Cat.--Contact metamorphism

B) Evans, B. W., 1964, Fractionation of elements in the pelitic hornfelses of the Cashel-Lough Wheelann intrusion, Connemara, Eire: Geochimica et Cosmochimica Acta, v. 28, no. 2, p. 127-156.

C) Purpose: provide information on absolute losses or gains of elements in pelitic hornfelses; examine trace element behavior under high T's in a rock/fluid system.

Methods: optical emission spectrography, flame photometry.

Results: evidence favors the fractional melting of the aureole rocks; extraction of interstitial liquids resulted in bulk chemical changes. There was no addition of elements during metasomatism. Alkali elements were extremely mobile; Cr, V, Co, Ga, Ni, Fe, Mg, and Ti were generally immobile except in extreme cases.

6. A) Gen. Cat.--Contact metamorphism

B) Green, D. H., 1964, The metamorphic aureole of the peridotite at The Lizard, Cornwall: Journal of Geology, v. 72, no. 5, p. 543-563.

C) Purpose: study variation in metamorphic assemblages in the aureole at Cornwall.

Methods: petrography, unspecified chemical analyses.

Results: the aureole is composed of these assemblages: brown-green hornblende, brown hornblende + hypersthene + augite, hypersthene + augite. The high temperature aureole is superimposed on moderate-grade regional metamorphism.

7. A) Gen. Cat.—Contact metamorphism

B) Villar-Fabre, G.F.; Quartino, B.J., 1966, Exomorphic and endomorphic effects from marble-contaminated granite contacts in the "San Miguel" quarry, Barker, Province of Buenos Aires, Argentina: American Journal of Science, v. 264, no. 4, p. 310-320.

C) Purpose: describe the effects of contact metamorphism on marble at San Miguel quarry.

Methods: petrography.

Results: the marble was intruded twice by granites. The first intrusion incorporated enough marble to change its composition to granodiorite-, tonalite-, and quartz-gabbro varieties. The later intrusion shows no signs of assimilation, but does show endomorphic effects at its margin. Endoskarn veins are composed mainly of grossular, clinozoisite, diopside, vesuvionite, and apatite. Wollastonite with some vesuvionite, grossular and clinozoisite form the exoskarn.

8 . A) Gen. Cat.--Contact metamorphism; microcline-orthoclase transition;
Eldora Stock, Colorado

B) Wright, T. L., The microcline-orthoclase transformation in the contact aureole of the Eldora Stock, Colorado: American Mineralogist, v. 52, no. 1 and 2, p. 117-136, 1967.

C) Purpose: to describe, in detail, the microcline-orthoclase transition along a single traverse from the Eldora stock into contact metamorphosed country rock.

Methods : petrography, chemical analyses, XRD.

Results: feldspars from pegmatites in Precambrian gneiss within 2770 feet of the Eldora stock were transformed from maximum microcline to orthoclase by contact metamorphism. In the range 2770 to 1130 feet a monoclinic and triclinic potassic phase coexist in perthitic intergrowth with albite of low-intermediate structural state. At greater distances perthites consisting of maximum microcline and low albite were unaffected, and at shorter distances the samples are composed of orthoclase and intermediate albite.

9 . A) Gen. Cat.--Contact metamorphism, wollastinite

B) Greenwood, H. J., 1967, Wollastinite: Stability in H_2O-CO_2 mixtures and occurrence in a contact-metamorphic aureole near Salma, British Columbia, Canada: American Mineralogist, v. 52, no. 11 and 12, p. 1669-1680.

C) Purpose: to present data and methods used in a study of the effect of diluting with H_2O the CO_2 produced during the formation of wollastinite.

Methods: experimental petrology, thermodynamic analyses, geologic mapping, petrography.

Results: it is shown that the occurrence of the mineral is best explained by reaction induced by flow of heat from the granitic intrusive, and that local variations in the topography of the isograd surface can be accounted for by a combination of the topography of the granite contact and variations in the H_2O content of the pore fluid.

10. A) Gen. Cat.--Contact metamorphism; microcline-orthoclase transition;
Eldora Stock, Colorado

B) Steiger, R. H.; Hart, S. R., 1967, The microcline-orthoclase transition within a contact aureole: American Mineralogist, vol. 52, no. 1 and 2, p. 87-116.

C) Purpose: to describe the distribution of orthoclase and microcline around the Eldora stock.

Methods: petrography, XRD.

Results: both the nature of the microcline-orthoclase transition and its distance from the contact depend strongly on the configuration of the contact in that particular area. In accordance with the heat flow calculations, the transition is relatively sharp and close (1200 feet or less) to protruding corners of the intrusive, whereas, near re-entrant sections of the intrusive, the transition is gradational and relatively distant (over 2400 feet) from the contact.

11. A) Gen. Cat.--Contact metamorphism

B) Ôba, N., 1968, Interchange of chemical components between granitic intrusions and aureole rocks of South Kyushu, Japan: Journal of Geology, v. 76, no. 4, p. 371-381.

Purpose: examine distribution of elements within contact aureoles.

Methods: petrography, unspecified chemical analyses.

Results: differences in Na and K distribution in various aureoles reflect different petrochemical properties of the intrusive bodies. The processes related to the distribution of elements in the aureoles are therefore related to the plutonic processes of granite emplacement. Movement of cations took place allochemically. The major control on element redistribution was the chemistry of the intrusive body.

12 . A) Gen. Cat.--Contact metamorphism

B) Woodard, H. H., 1968, Contact alteration in the north wall of the Cape Neddick gabbro, Maine: Journal of Geology, v. 76, no. 2, p. 191-204.

C) Purpose: describe mineralogical and chemical aspects of contact reactions in the Cape Neddick gabbro.

Methods: petrography, spectroscopy, flame photometry.

Results: the gabbro has been hydridized by assimilation of wall rock inclusions, gain of Ca, Ti, and Al and depletion of Fe and Mg during contact reactions. Sanidinite-facies metamorphism extends for at least 24 feet from the contact and is explained by relocation of wallrock Si and K farther into the wallrock, probably accompanied by migration of volatile H_2O and CO_2 derived from breakdown of biotite and calcite in the wallrock.

13. A) Gen. Cat.—Contact metamorphism

B) Gaurilin, R. D.; Pevtsova, L. A.; Klassova, N. S., 1969, Behavior of lead and zinc in contact metamorphism of arenaceous shales around intrusions of various compositions: Geochemistry International, v. 6, no. 2, p. 251-261.

C) Purpose: examine behavior of ore elements during contact metamorphism of sandy shales.

Methods: petrography, spectrophotometry with dithizone.

Results: there was no exchange of Pb or Zn from the intrusions to the country rock. This may be due to a lack of fluids. The behavior of Pb, and possibly Zn, is independent of the grade of metamorphism.

14 . A) Gen. Cat.--Contact metamorphic deposits, uranium

B) Harshman, E. N.; Bell, K. G., 1970, Uraninite-bearing contact metamorphic deposits, Heaths Peak, Carbon County, Wyoming: Economic Geology, v. 65, no. 7, p. 849-855.

C) Purpose: to describe the uranium-bearing contact metamorphic deposits at Heaths Peak.

Methods: geologic mapping, petrography.

Results: the deposits containing uraninite and sulfide minerals display a zoned distribution of metals from the edge of the granite into adjacent metamorphic rocks. The metallic minerals - uraninite, molybdenite, pyrite, chalcopyrite, galena, pyrrhotite, and marcasite - are concentrated on the undersides of metamorphosed roof pendants. At the Little Man mine, deposition was related to a small cupola projecting into the central part of an elongate pendant.

15. A) Gen. Cat.--contact metamorphism, limestones <u>or</u> Aureoles, basaltic intrusions

B) Reverdatto, V. V., 1970, Pyrometamorphism of limestones and the temperature of basaltic magmas: Lithos, v. 3, p. 135-143.

C) <u>Purpose</u>: to describe calc-silicate rocks which have been subjected to thermal metamorphism (sanidinite or spurrite-merwinite facies). The rocks are from three localities on the Siberian Platform.

<u>Methods</u>: petrography.

<u>Results</u>: the metamorphosed rocks described all formed in the aureoles of subvolcanic basaltic intrusions. The temperature of metamorphism, as estimated from the earlier published experimental data, is about 800-1000°C, whilst the temperature of the basaltic magma is believed to have been not less than 1200°C.

16. A) Gen. Cat.--Contact metamorphism

B) Hofman, A., 1972, Chromatographic theory of infiltration metasomatism and its application to feldspars: American Journal of Science, v. 272, no. 1, p. 69-90.

C) Purpose: review infiltration models in light of chromatographic theory.

Methods: derivations based on thermodynamic theory.

Results: the isothermal infiltration model is identical to an ion exchange process in a column with local equilibrium. Shape and velocity of a replacement front in a 2-component ion-exchange column depends on variation in the concentration of a component in fluid versus in the solid. These results can be applied to multi-component systems. Experimental examination of diffusion of K into pure albite fit the model well.

17. A) Gen. Cat.--Contact metamorphism

B) Trommsdorf, V.; Evans, B.W., 1972, Progressive metamorphism of antigorite schist in the Bergell tonalite aureole (Italy): American Journal of Science, v. 272, no. 5, p. 423-437.

C) Purpose: examine progressive metamorphism in the Bergell aureole.

Methods: petrography, microprobe.

Results: four zones have been delineated. In order of increasing grade, they are: 1) antigorite-olivine-diopside; 2) antigorite-olivine-tremolite; 3) talc-olivine-tremolite; 4) anthophyllite-olivine-tremolite. This sequence is consistent with equilibrium data. Order of preference for Fe relative to Mg is: anthophyllite $>$ olivine $>$ antigorite $>$ tremolite $>$ diopside $>$ talc.

18 . A) Gen. Cat.--Contact metamorphism

B) Blatter, C. L.; Roberson, H. E.; Thompson, G.R., 1973, Regularly interstratified chlorite-dioctahedral smectite in dike-intruded shales, Montana: Clays and Clay Minerals, v. 21, no. 4, p. 207-212.

C) Purpose: describe a pure corrensite that occurs in dike-intruded shales.

Methods: petrography, XRD, wet chemical methods.

Results: corrensite, in this area, is the result of alteration of shale and siltstone caused by fluids accompanying intrusions. This material is a regularly interstratified series of chlorite and dioctahedral smectite layers.

19 . A) Gen. Cat.--Contact metamorphism

B) Gaurilin, R. D.; Devina, O. A., 1973, Behavior of phosphorus in contact metamorphism of sandy shales around intrusions of various compositions: Geochemistry International, v. 10, no. 2, p. 413-417.

C) Purpose: examine geochemistry of P in relation to exocontact metamorphism.

Methods: colorimetry.

Results: P is basically inert during contact metamorphism of shales by various granite bodies. There is no transfer of P from the intrusion, to the surrounding country rocks.

20 . A) Gen. Cat.--Contact metamorphism, prehnite

B) Robinson, D., 1973, Prehnite from the contact metamorphic aureole of the Whin Sill Intrusion, northern England: American Mineralogist, v. 58, no. 1 and 2, p. 132-133.

C) Purpose: to describe prehnite from the contact aureole of the Whin Sill.

Methods: petrography, electron microprobe.

Results: as relatively few analyses are available, no particular variation in composition of the prehnite can be correlated with distance from the intrusive contact. It is worthy to note, however, that eight of the ten point analyses from samples within 0.1 m of the contact, show appreciable substitution, while the two analyses of a sample, 5.5 m from the contact, show virtually no substitution.

21 . A) Gen. Cat.--Contact metamorphism or Behavior of actinides in geomedia

B) Yermolayev, N. P., 1973, Uranium and thorium in regional and contact metamorphism: Geochemistry International, v. 10, no. 2, p. 418-423.

C) Purpose: consider radioelement distribution during metamorphism.

Methods: calculations based on published data, literature review.

Results: U is mobilized early during regional or contact metamorphism. As T and P increase, Th is also mobilized and Th/U decreases. U and Th are carried upward through the crust by water and/or CO_2. This continues until rock melting occurs. Highly radioactive melts may then be generated. Regressive metamorphism involves local metasomatic accumulation of radioelements.

22 . A) Gen. Cat.--Contact metamorphism

B) Joesten, R., 1974, Local equilibrium and metasomatic growth of zoned calc-silicate nodules from a contact aureole, Christmas Mountains, Big Bend region, Texas: American Journal of Science, v. 274, no. 8, p. 876-901.

C) Purpose: construct a growth model based on the initial and final states of the system.

Methods: petrography, microprobe.

Results: the inferred prograde sequence in these carbonates is:

calcite - quartz

calcite - wollastonite

calcite - tilleyite - wollastonite

calcite - tilleyite - spurrite - rankinite - wollostonite

calcite - spurrite - rankinite - wollostonite

Assemblages indicate that $x_{CO_2} \geq 0.6$ in the fluids. T's ranged from 925-1025°C at the contact to 565-600°C at 70m away. CaO, SiO_2 and CO_2 were distributed in growing nodules by diffusion. Chemical potentials of diffusing components in a monomineralic zone are controlled by 2-phase equilibria at zone boundaries.

23 . A) Gen. Cat.--Contact metamorphism or Hydrothermal alteration

B) Bonatti, E.; Honnorez, J.; Kirst, P.; Radicati, F., 1975, Metagabbros from the Mid-Atlantic Ridge at 06°N: contact-hydrothermal-dynamic metamorphism beneath the axial valley: Journal of Geology, v. 83, no. 1, p. 61-78.

C) Purpose: describe origin and discuss significance of amphibolitic metagabbros from the Mid-Atlantic Ridge.

Methods: petrography, XRD, microprobe, fission-track method.

Results: composition of metagabbros appears nearly unchanged from that of their parent rocks. Metamorphism took place at less than 1.5 km depth, and could not be explained by burial alone. Contact, dynamic, and hydrothermal processes account for present rock mineralogy. Fault-shear zones allowed infection of basaltic dikes and circulation of hydrothermal fluids.

24 . A) Gen. Cat.--Contact metamorphism

B) Hanson, G. N.; Simmons, K. R.; Benre, A. E., 1975, $^{40}Ar/^{39}Ar$ spectrum ages for biotite, hornblende, and muscovite in a contact metamorphic zone: Geochimica et Cosmochimica Acta, v. 39, no. 9, p. 1269-1277.

C) Purpose: determine whether the $^{40}Ar/^{39}Ar$ technique can distinguish varying amounts of Ar loss from minerals.

Methods: petrography,electron microprobe, mass spectrometry.

Results: biotite and hornblende give $^{40}Ar/^{39}Ar$ ages that are comparable to the K-Ar ages for these samples. $^{40}Ar/^{39}Ar$ ages from muscovite tend to be relatively high. The rate-controlling process of Ar loss from biotite may be volume diffusion or recrystallization without a change in major element composition.

25 . A) Gen. Cat.—Contact metamorphism

B) Morgan, B.A., 1975, Mineralogy and origin of skarns in the Mount Morrison pendant, Sierra Nevada, California: American Journal of Science, v. 275, no. 2, p. 119-142.

C) Purpose: describe mineralogy and petrology of skarns associated with a granodiorite pluton.

Methods: petrography, microprobe.

Results: 2 trends for skarn development are illustrated: 1) toward an oxidized skarn with Fe present in andradite; 2) toward a reduced skarn with Fe present in hedenbergite. Retrograde reactions produce deposits characterized by epidote and amphibole, respectively. Variation in oxidation results from the mixing of different liquids from magmatic sources.

26 . A) Gen. Cat.--Contact metamorphism

B) Berg, J. H.; Wheeler, E. P., 1976, Osumilite of deep-seated origin in the contact aureole of the anorthositic Nain Complex, Labrador: American Mineralogist, v. 61, no. 1 and 2, p. 29-37.

C) Purpose: to report a new and radically different natural occurrence of osumilite from near Naina, Labrador, Canada, in a granulite within the contact aureole of the anorthositic Nain complex.

Methods: petrography, chemical analyses, electron microprobe, XRD.

Results: osumilite occurs with quartz, hypersthene, orthoclase, cordierite, plagioclase, graphite, and pyrrhotite in the contact aureole of the Precambrian anorthositic Nain complex. Although experimental and other natural evidence has indicated that osumilite is a metastable low-pressure phase, the textures and chemical homogeneity of the Nain osumilite indicate that it formed as a stable phase.

27 . A) Gen. Cat.--Contact Metamorphism

B) Frantz, J.D.; Mao, H.K., 1976, Bimetasomatism resulting from intergranular diffusion: I. A theoretical model for monomineralic reaction zone sequences: American Journal of Science, v. 276, no. 7, p. 817-840.

C) Purpose: develop a model for growth in monomineralic zones.

Methods: calculations based on published data.

Results: total zone growth rate is represented by:

$$dL_j/dt = \sum_{k}^{n} R_{jk}/L_k$$

where L_j is the thickness of zone j, t is time, and R_{jk} is a constant = 0 when $k < j - 1$ or $k > j + 1$.

28. A) Gen. Cat.--Contact metamorphism, carbonate rocks

B) Joesten, R., 1976, High-temperature contact metamorphism of carbonate rocks in a shallow crustal environment, Christmas Mountains, Big Bend region, Texas .

C) Purpose: to describe the mineralogy and contact relations of a composite stock of alkali gabbro and syenite that has intruded a limestone.

Methods: petrography, electron microprobe, thermodynamic analyses.

Results: assuming similar fluid composition, the temperature of skarn growth was essentially the same at the intrusive contact and in xenoliths enveloped by gabbroic magma, and was in the range 920 to 1035°C.

29 . A) Gen. Cat.—Contact metamorphism

B) Weare, J.H.; Stephens, J.R.; Eugster, H.P., 1976, Diffusion metasomatism and mineral reaction zones: General principles and application to feldspar alteration: American Journal of Science, v. 276, no. 7, p. 767-816.

C) Purpose: apply theory of irreversible thermodynamics to metasomatic reaction zones.

Methods: calculations based on published data.

Results: the diffusion equation derived in this paper can be used to solve for one-dimensional diffusion of one and two components. Zone thickness growth follows a parabolic growth law. The equation has been applied to feldspar alteration and holds for flushed systems.

30. A) Gen. Cat.--Contact metamorphism

B) Rice, J.M., 1977, Progressive metamorphism of impure dolomitic limestone in the Marysville aureole, Montana: American Journal of Science, v. 277, no. 1, p. 1-24.

C) Purpose: present data on phase equilibria and role of fluid composition during metamorphism.

Methods: petrography, microprobe.

Results: spatial distribution of the observed parageneses requires buffering of the CO_2/H_2O ratio in the fluid phase. Distinctive changes in parageneses at isograd boundaries are due to reaction at isobaric invariant points and singular points ($T\text{-}X_{CO_2}$ maxima). Data indicate equilibrium was generally attained and confirm the low variance of both zone and isograd assemblages.

31. A) Gen. Cat.--Contact metamorphism

B) Rice, J. M., 1977, Contact metamorphism of impure dolomitic limestone in the Boulder Aureole, Montana: Contributions to Mineralogy and Petrology, v. 59, no. 3, p. 237-259.

C) Purpose: to describe the contact metamorphism of silica-undersaturated, aluminous carbonate rocks surrounding the northernmost portion of the Boulder batholith.

Methods: petrography, electron microprobe.

Results: the progressive metamorphism in the Boulder aureole has resulted in a consistent sequence of uniformly distributed zones of low variance mineral assemblages which are separated by abrupt and distinctive isograds.

32 . A) Gen. Cat.--Contact metamorphism

B) Suzuki, K., 1977, Local equilibrium during the contact metamorphism of siliceous dolomites in Kasuga-mura, Gifuken, Japan: Contributions to Mineralogy and Petrology, v. 61, no. 1, p. 79-89.

C) Purpose: to study the behavior of intergranular fluids during the metamorphism. This study is based on temperatures estimated with the dolomite-calcite solvus geothermometry.

Methods: petrography, electron microprobe, dolomite-calcite geothermometry.

Results: the dolomite-calcite solvus geothermometry gives temperatures of 465°C for the assemblage dolomite-quartz-talc-tremolite-calcite, 555°C for the assemblage dolomite-quartz-tremolite-diopside-calcite, and 595°C for the assemblage dolomite-tremolite-diopside-forsterite-calcite. Equilibrium fluid pressures, calculated with available experimental data are 2.6 kb for the first five-mineral assemblage, and 3.5 kb for the latter two. Fluid compositions were controlled by reactions in each local system, but changed toward a water-rich one when the reactions ceased.

33 . A) Gen. Cat.--Contact metamorphism

B) Ferry, J.M., 1978, Fluid interaction between granite and sediment during metamorphism, south-central Maine: American Journal of Science, v. 278, no. 8, p. 1025-1056.

C) Purpose: document granite-sediment-fluid interaction during emplacement of granitic stocks.

Methods: petrography, microprobe.

Results: partial conversion of Ca-plag + calcite to zoisite in metacarbonates resulted in net addition of H_2O to, and loss of CO_2 from, the carbonate rock. The CO_2 was added to the granite as feldspars altered to carbonate-bearing assemblages. Various geothermometers in the granites give a range of temperatures (650-425°C). Volumetric fluid/rock ratios have been calculated and vary from 0.001 far away from the intrusions to 0.19 close to the stocks.

34 . A) Gen. Cat.--Contact metamorphism

B) Frenkel, M. Y., 1978, Computer solution of the heat and mass transport equations for the emplacement of a sill: Geochemistry International, v. 15, no. 2, p. 162-170.

C) Purpose: design an algorithm for solving heat and mass transfer equations for the emplacement of a sill.

Methods: computer modelling (Fortran IV)

Results: an explicit 4-point finite difference scheme is used. The program utilizes input data on heat content, composition of the phase mixture, and the crystallization diagram to temperature and phase composition at any given time. The program also simulates the melting process of the mixture. Most difficulties in solving heat and mass transfer equations during these complicated phase interactions are thus eliminated.

35 . A) Gen. Cat.--Contact metamorphism

B) Kwak, T.A.P., 1978, Mass balance relationships and skarn forming processes at the King Island scheelite deposit, King Island, Tasmania, Australia: American Journal of Science, v. 278, no. 7, p. 943-968.

C) Purpose: describe bulk chemical and geometric relationships in the King Island deposit.

Methods: petrography, microprobe.

Results: 2 main environments of skarn formation occur: 1) replacement of marble layers by skarn in massive hornfels; 2) replacement of marble layers by hornfelsic interlayers. Skarn forming reactions liberated large amounts of Na, K, S, H_2O, and CO_2. Replacement of parent hornfels and marble is a constant volume process.

36 . A) Gen. Cat.--Contact metamorphism

B) April, R. H., 1980, Regularly interstratified chlorite luermiculite in contact metamorphosed red beds, Newark Group, Connecticut Valley: Clays and Clay Minerals, v. 28, no. 1, p. 1-11.

C) Purpose: characterize and propose a model of formation for interstratified clays in red beds.

Methods: XRD, microprobe, wet chemical analyses.

Results: regularly interstratified chlorite/vermiculite is restricted to a 2.5 m wide zone adjacent to and underlying the Hampden Basalt. Near the contact, hydrothermal fluids provided Mg; further from the contact, Mg was provided by thermal dissociation of dolomite. The interstratified layer probably formed from pre-existing vermiculite or illite as K^+ was released and brucitic sheets were incorporated into interlayer positions.

37. A) Gen. Cat.--Contact metamorphism

B) Harrison, T. M.; MacDougall, I., 1980, Investigations of an intrusive contact, northwest Nelson, New Zealand - I. Thermal, chronological, and isotopic constraints: Geochimica et Cosmochimica Acta, v. 44, no. 12, p. 1985-2003.

C) Purpose: use mineral dates and numerical analysis of the thermal history of the Separation Point Batholith (114 million years old).

Methods: mass spectrometry, XRD, fission track, AAS, thermal conductivity and porosity measurements.

Results: contact metamorphism disturbed K-Ar systematics in surrounding rocks. Intrusion mineral ages and closure temperature estimates indicate that the batholith cooled at an exponentially decreasing rate reaching 100°C by 75 million years ago. Oxygen isotope and permeability data confirm conduction as the cooling mechanism for the intrusion. A heat flow model indicates that temperatures in the country rock at the contact were elevated 600°C, but 5 km away were raised only 50°C.

38. A) Gen. Cat.--Contact metamorphism

B) Harrison, M. T.; McDougall, I., 1980, Investigations of an intrusive contact, northwest Nelson - II. Diffusion of radiogenic and excess ^{40}Ar in hornblende revealed by $^{40}Ar/^{39}Ar$ spectrum analysis: Geochimica et Cosmochimica Acta, v. 44, no. 12, p. 2005-2020.

C) Purpose: use the $^{40}Ar/^{39}Ar$ ratio to determine the effects of the intrusion on minerals, obtain diffusion coefficients for hornblende, obtain a better age for country rock.

Methods: mass spectrometry.

Results: $^{40}Ar/^{39}Ar$ age spectrum technique can resolve ^{40}Ar diffusion gradients in hornblende. Age of country rock (Rameka gabbro) is 367 ± 5 million years. Calculated and laboratory data yield a well defined diffusion law. Local excess ^{40}Ar developed in the gabbro on time scales from 10^4 to 10^6 years. Ar partial pressure was at least 10^{-2} bars in places. The age spectrum technique can provide close estimates of reheating and crystallization ages in hornblende.

39. A) Gen. Cat.--Contact metamorphism

B) Neiva, A. M. R., 1980, Chlorite and biotite from contact metamorphism of phyllite and metagraywacke by granite, aplite-pegmatite and quartz veins: Chemical Geology, v. 29, no. 1/2, p. 49-71.

C) Purpose: to record new data on the geochemistry of chlorite and biotite of contact metamorphism produced by the sequence of granite → aplite - pematite → quartz veins.

Methods: petrography, chemical analyses (AA, wet chemistry).

Results: in the metamorphic rocks around the granite, the chlorites show an increase in contents of Ti, Fe^{3+} + Fe^{2+} and K and the biotites show an increase in Ti content on passing from the outer zone to the inner zone of contact metamorphism. The magnitude of the increase decreases progressively as the aplite-pegmatite and quartz veins are approached. Contents of Al, Mg, Cr, V, Zn, Ni, Co, Sc, Ce, and La decrease in chlorites and of Mg, Cr, V, Ni, Co, Pr, Ce, and La decrease in biotites on passing from the outer to the inner zone.

40. A) Gen. Cat.--Contact metamorphism

B) Vaniman, D. T.; Papike, J. J.; Labotka, T., 1980, Contact metamorphic effects of the Stillwater Complex, Montana: American Mineralogist, v. 65, no. 11 and 12, p. 1087-1102.

C) Purpose: to evaluate the metamorphic conditions within the iron formation at five localities along the base of the igneous intrusion.

Methods: field sampling, electron microprobe.

Results: the Stillwater Iron Formation provides mineralogical constraints on minimum prograde temperatures near the contact (≤800°C).

41 . A) Gen. Cat.--Contact metamorphism

B) Bucher-Nurminen, K., 1981, The formation of metasomatic reaction veins in dolomitic marble roof pendants in the Bergell intrusion (Province Sondrio, Northern Italy): American Journal of Science, v. 281, no. 9, p. 1197-1222.

C) Purpose: describe zoned metasomatic reaction veins in dolomitic roof pendants.

Methods: petrography, microprobe.

Results: mineral assemblages in individual zones include: calcite + olivine; calcite + diopside; calcite + amphibole; calcite + antigorite; calcite + talc. Most abundant vein type calcite and internally banded amphibole. The transport process for many of the veins was infiltration metasomatism. MgO was conserved during metasomatism, although Fe and Al were transported as well.

42 . A) Gen. Cat.--Contact Metamorphism

B) Jamieson, R. A.; Strong, D. F., 1981, A metasomatic mylonite zone within the ophiolite aureole, St. Anthony complex, Newfoundland: American Journal of Science, v. 281, no. 3, p. 264-281.

C) Purpose: document metasomatism due to the migration of fluids through shear zones.

Methods: petrography, microprobe.

Results: field relations indicate that the mylonite was derived from aureole rocks after the metamorphic sequence was established, but before metamorphism had ceased. Metasomatism involved the addition of volatiles and K, Rb, Ba, and removal of Mg, Fe, Na, Ca. Replacement of hornblende by biotite, garnet, and quartz also occurred.

43 . A) Gen. Cat.--Contact metamorphism; Clay minerals

B) Labotka, T. C.; Papike, J. J.; Vaniman, D. T.; Morey, G. B., 1981, Petrology of contact metamorphosed argillite from the Rove Formation, Gunflint Trail, Minnesota: American Mineralogist, v. 66, no. 1 and 2, p. 70-86.

C) Purpose: to characterize the distribution of elements among coexisting mineral in low-pressure pelitic schists.

Methods: petrography, XRD, electron microprobe.

Results: the control metamorphic effects of the Duluth Complex on the argillaceous Rove Formation are confined to the region within a few hundred meters of the contact. This is in sharp contrast to the contact metamorphic effects on the Gunflint Iron Formation, which preserved prograde reactions as far as 10 km from the contact. The differences between the iron-formation and the Rove Formation are, in part, the result of the large number of iron silicates that may occur in rocks poor in aluminum and potassium.

44 . A) Gen. Cat.--Contact metamorphism <u>or</u> Behavior of clay minerals in geomedia

B) Nadeau, P. H.; Reynolds, R. C., Jr., 1981, Burial and contact metamorphism in the Mancos Shale: Clays and Clay Minerals, v. 29, no. 4, p. 249-259.

C) <u>Purpose</u>: determine distribution of illite/smectite (I/S) interlayers in the Mancos Shale and examine effects of diagenesis on clay mineralogy and chemistry.

<u>Methods</u>: XRD.

<u>Results</u>: the regional distribution of ordered vs. random stratification in I/S is consistent with burial metamorphism, correlating with rank of coal and Laramide tectonism. Contact metamorphism by Tertiary intrusions resulted in a similar clay suite. I/S changes from random to ordered interstratification between the 100^{o} and 150^{o}C isotherm (about 5 km from intrusive center). Chemical variation (the presence or absence of carbonate, in particular) affects early diagenetic reactions.

45 A) Gen. Cat.-- Contact metamorphism or Hydrothermal alteration

B) Parmentier, E. M.; Schedl, A., 1981, Thermal aureoles of igneous intrusions: some possible indications of hydrothermal convective cooling: Journal of Geology, v. 89, no. 1, p. 1-22.

C) Purpose: examine size and shape of thermal aureoles as possible indicators of hydrothermal convective heat transport.

Methods: development of numerical models based on published data.

Results: use of the model presented (illustrating the effect of convective cooling on maximum temperatures attained in the country rock) suggests the El Salvador porphyry copper deposit cooled convectively. The shape of the low temperature aureole around the Mull intrusive complex can also be explained by convective cooling, while the cooling history of the Cuillin gabbro on Skye remains ambiguous. For a 10 km wide intrusion, convective cooling is important for country rock with permeabilities greater than a few hundredths of a millidarcy.

46. A) Gen. Cat.--Contact metamorphism

B) Simoneit, B. R. T.; Brenner, S.; Peters, K. E.; Kaplan, I. R., 1981, Thermal alteration of Cretaceous black shale by diabase intrusions in the Eastern Atlantic-II. Effects on bitumen and kerogen: Geochimica et Cosmochimica Acta, v. 45, no. 9, p. 1581-1602.

C) Purpose: monitor the thermal effects resulting in expulsion of volatile organics and alteration of residual organic matter.

Methods: gas chromatography, gas chromatography-mass spectrometry, electron spin resonance and chemical analysis.

Results: hydrocarbons decrease in concentration near the intrusions. Thermally altered regions contain S^o and an excess of pristane over phytane; unaltered rock contains no S^o and more phytane than pristane. Thermally altered kerogen contains only traces of humic material; enrichments in ^{13}C, ^{34}S and D all occur,as expected. The overall effect of the intrusions was to generate and expel petroliferous material from the vicinity of the shales.

47\. A) Gen. Cat--Contact metamorphism

B) Bowman, J. R.; Essene, E. J., 1982, P-T-X(CO_2) conditions of contact metamorphism in the Black Butte aureole, Elkhorn, Montana: American Journal of Science, v. 282, no. 3, p. 311-340.

C) Purpose: evaluate P-T-X(CO_2) conditions in marbles.

Methods: microprobe, petrography.

Results: application of calcite-dolomite solvus thermometry and phase equilibria at an estimated P = 1 kb allows estimate of fluid composition and temperature at each isograd:

$T = 400 - 450^\circ C$ $\quad$ $.50 < X_{CO_2} < .96$

$T = 500 - 550^\circ C$ $\quad$ $.05 < X_{CO_2} < .55$

$T = 590 - 600^\circ C$ $\quad$ $.04 < X_{CO_2} < .07$

These limits indicate a significant decrease in X(CO_2) with increasing grade. Calculations show that fluid flux is an important factor that influences internal fluid buffering.

48. A) Gen. Cat.--Contact Metamorphism

B) Frisch, C. J.; Helgeson, H. C., 1984, Metasomatic phase relations in dolomites of the Adamillo Alps: American Journal of Science, v. 284, no. 2, p. 121-185.

C) Purpose: provide information on the chemical composition of minerals and fluids and mineral paragenesis during metasomatism.

Methods: petrography, microprobe.

Results: 5 mineral zones are present near the intrusive contact: 1) calcite and forsterite; 2) diopside; 3) diopside + tremolite + clinozoisite + chlorite; 4) clinozoisite ± plagioclase; 5) silica-enriched zone. Highest Fe/Mg is found in zones 4) and 5) (i.e., nearest the intruded quartz diorite). Metasomatism involved the loss of CO_2 and Na, and the addition of Si, Mg, Fe, and K to the country rock. Metasomatism was accomplished over thousands of years by an H_2O rich fluid ($X_{CO2} \leq 0.021$) at pressures $\leq$ 1 kbar and T between 400 and 440°C.

49 . A) Gen.Cat.--Contact metamorphism

B) Sack, R. O., 1982, Reaction skarns between quartz-bearing and olivine-bearing rocks: American Journal of Science, v. 282, no. 7, p. 970-1011.

C) Purpose: examine reaction skarns between feldspathic cumberlandite, a plagioclase-quartz dike, and a quartz vein.

Methods: petrography, microprobe.

Results: orthopyroxene develops between quartz-bearing and forsterite olivine-bearing rocks. Metamorphic conditions were $T = 730 \pm 50^{\circ}C$; $P = 8 \pm 1$ kbar. Assemblages indicate extreme disequilibrium. Relative mobility of oxides is as follows: $CaO \geqq FeO > MgO > SiO_2 > AlO_{3/2}$. Inferred changes in Fe/Fe + Mg may be due to retrograde cooling or polymetamorphism.

50 . A) Gen. Cat.--Contact metamorphism

B) Velde, B.; Brusewitz, A. M., 1982, Metasomatic and non-metasomatic low grade metamorphism of Ordovician meta-bentonites in Sweden: Geochimica et Cosmochimica Acta, v. 46, no. 3, p. 447-452.

C) Purpose: assess chemical variations in Ordovician metabentonites at Kinnekulle, Sweden.

Methods: petrography, microprobe, crystal spectrometry, bulk rock analysis.

Results: K is the most important element in the transformation of volcanic ash to bentonite. Low grade metamorphism does not greatly effect major element chemistry, however, minor elements can be mobile, as evidenced by Rb and Sr abundances.

51 . A) Gen. Cat.--Contact metamorphism

B) Attoh, K.; VanderMeulen, M. J., 1984, Metamorphic temperatures in the Michigamme Formation compared with the thermal effect of an intrusion, northern Michigan: Journal of Geology, v. 92, no. 4, p. 417-432.

C) Purpose: evaluate sources of heat in the metamorphic Michigamme Formation.

Methods: petrography, calculations based on published data.

Results: garnet-biotite geothermometry yields temperatures ranging from 487° to 592°C in various zones of the Michigamme Formation, with increasing temperatures toward the intrusion. Modelling of heat flow from the intrusion produced temperatures that are significantly lower than those given by geothermometry. Thus, the intrusion was not the only heat source during metamorphism and the effects of this thermal perturbation were superimposed on a high regional temperature.

52. A) Gen. Cat.--Contact Metamorphism

B) Bowman, J. R.; Essene, E. J., 1984, Contact skarn formation at Elkhorn, Montana. I: P-T-component activity conditions of early skarn formation: American Journal of Science, v. 284, no. 6, p. 597-650.

C) Purpose: obtain detailed information on the physico-chemical variables involved in skarn petrogenesis.

Methods: petrography, electron microprobe.

Results: early skarn formation includes 2 stages: 1) development of 3 or 4 phase assemblages that usually include garnet and pyroxene and occasionally epidote, vesuvionite or clintonite; 2) replacement of garnet and pyroxene by epidote, amphibole, clintonite, chlorite, calcite, and quartz. Later stages include quartz-axinite veining and chloritization of pyroxene. Early garnets and pyroxenes show wide variation in chemical composition. P-T for stage 1 are $T = 525 \pm 35^{\circ}C$; $P = 1 \pm 0.3$ kbar. Stage 2 occurs at $T \leq 470^{\circ}C$ in a water rich fluid. Metasomatism at this site cannot be modeled by simple diffusion or infiltration.

ELEMENT MOBILITY: TRACE ELEMENTS, ELEMENT TRANSPORT, MIGRATION, AND DISTRIBUTION

1. A) Gen. Cat.--Behavior of trace elements in geomedia

   B) Brown, R. M., 1961, Hydrology of tritium in the Ottawa Valley: Geochimica et Cosmochimica Acta, v. 21, no. 3 and 4, p. 199-216.

   C) Purpose: consider use of tritium in hydrologic modelling.

   Methods: low background gas counting.

   Results: calculated turnover rate is 0.27/year for a reservoir of 2.1 m. The amount of fresh precipitation in re-evaporated water is estimated at 55 ± 1%. Correlation of ^3H concentration provided by the model could be adapted to function in other areas.

2 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Newton, R.; Round, G. F., 1961, The diffusion of helium through sedimentary rocks: Geochimica et Cosmochimica Acta, v. 22, no. 2-4, p. 106-132.

C) Purpose: examine means of migration of He through sedimentary rocks.

Methods: calculations based on published data.

Results: mathematical modeling reduces this problem to one-dimensional diffusion, and can be solved with various boundary conditions. Each layer interface can be accounted for. Single and double layer models agree well with observed data.

3 . A) Gen. Cat.--Element migration

B) Rosholt, J. N., Jr., 1961, Uranium migration and geochemistry of uranium deposits in sandstone above, at, and below the water table: Part I. Calculation of apparent dates of uranium migration in deposits above and at the water table: Economic Geology, v. 56, no. 8, p. 1392-1403.

C) Purpose: to introduce methods of calculating the apparent maximum and minimum ages for deposits above and at the water table.

Methods: radiochemical analyses, age calculations.

Results: this study concerned the distribution of the radioactive daughter products, which serve as natural tracers in the migration of uranium. The primary assumption is that the proactinium and thorium do not migrate in measurable quantities from the place where they were produced by the decay of the parent uranium isotopes. The upper limit of age determination is about 250,000 years, based on the half-lives of Pa^{231} and Th^{230}.

4 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Mazor, E., 1962, Radon and radium content of some Israeli water sources and a hypothesis on underground reservoirs of brines, oils, and gases in the Rift Valley: Geochimica et Cosmochimica Acta, v. 26, no. 7, p. 765-786.

C) *Purpose*: investigate anomalous Ra and Rn in groundwaters in Israel.

Methods: Geiger counter.

Results: highest Ra and Rn concentrations were found in the Jordan Rift Valley. Rn concentration ranged from 2μμc/liter to 21,300 μμc/liter. Most waters had Ra concentrations < 2μμc/liter; some reached 180 and even up to 1000 μμc/liter. Results indicate that Rn is more mobile and reaches the surface easier than Ra. There is no relationship between Ra or Rn with temperature or salinity of the water.

5 . A) Gen. Cat.--Element distribution

B) Shrivastava, J. N.; Proctor, P. D., 1962, Trace element distribution in the Searchlight, Nevada quartz monzonite stock: Economic Geology, v. 57, no. 7, p. 1062-1070.

C) Purpose: to determine if petrographic and spectrochemical work on selected samples from the intrusive mass might prove helpful in finding criteria to distinguish a "productive" from a non-productive intrusive body.

Methods: petrography, chemical analyses (spectrography)

Results: the results show certain trends. The contents of Ni and Zr are little different between the hypothetical fresh and altered rock. Ge, V, Mn, and Sr are in lesser quantities in the altered rock. Pb, Cu, V, and Mn, occur as elements in the vein system of the surrounding rocks. Sr and Ga have not been reported from the veins.

6 . A) Gen. Cat.--Element transport

B) Borina, A. F., 1963, Aqueous salt solutions at high pressures and temperatures as a possible media of transport of ore-forming elements in hydrothermal processes: Geochemistry, no. 7, p. 681-690.

C) Purpose: investigate the problem of transporting ore compounds.

Methods: none discussed.

Results: $CaMoO_4$ dissolves congruently in chloride solutions ($KCl:NaCl=2.2:1$). Solubility increases with increasing salt content at all temperatures from 300°C to 500°C. In solutions with chloride concentration $\geq$ 25 wt. %, the temperature coefficient of $CaMoO_4$ solubility is positive; it is negative for concentrations lower than 8-10 wt. %.

7. A) Gen. Cat.--Element distribution

B) Friedrich, G. H., and Hawkes, H. E., 1966, Mercury dispersion halos as ore guides for massive sulfide depsosits, West Shasta district, California: Mineralium Deposita, v. 2, no. 3, p. 77-88.

C) Purpose: to determine whether the mercury-halo prospecting method could be applied successfully in the West Shasta district.

Methods: chemical analyses (absorption)

Results: Mercury was determined in residual soils derived from apparently unmineralized rocks at stratigraphic levels from 50 to 200 feet over known ore at the Early Bird, Keystone, and Mammoth miners. In each case, pronounced mercury anomalies were found.

8. A) Gen. Cat.--Element mobility; hydrothermal alteration

B) Floyd, P. A., 1967, The role of hydration in the spatial distribution of metasomatic cations in the Lands End aureole, Cornwall: Chem . Geol., v. 2, p. 147-156.

C) Purpose: to describe the distribution of selected major and trace elements in the Land's End granite aureole, Cornwall.

Methods: chemical analyses (unspecified)

Results: as element migration took place in a dominantly aqueous environment, it is suggested that the metasomatic cations were in the hydrated state and not in the "bare"ionic state. If this were the case, their spatial distribution relative to the granite contact could be explained in terms of the relative sizes of the hydrated species. That is, large highly hydrated ions would be less mobile than smaller hydrated ions and thus be restricted in their movement and distribution.

9 . A) Gen. Cat.--Element mobility

B) Mueller, R. F., 1967, Mobility of the elements in metamorphism: Journal of Geology, v. 75, no. 5, p. 565-582.

C) <u>Purpose</u>: examine interplay of kinetic and thermodynamic factors that contribute to compositional variation in metamorphic rocks.

<u>Methods</u>: petrography, calculations based on published data.

<u>Results</u>: although lattice diffusion is ineffective as a means of mass transport, it is important in bringing about local equilibrium. According to the quasi-equilibrium diffusion model presented here, compositional gradients may be established by diffusion of certain critical molecular or ionic species. Application of the model to variation in $Mg/(Mg + Fe^{2+})$ is similar to observed trends. Classification of elements or molecules as "mobile" or " inert" has no basis in theory or experiment.

10. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Björnsson, S., 1968, Radon and water in volcanic gas at Surtsey, Iceland: Geochimica et Cosmochimica Acta, v. 32, no. 8, p. 815-821.

C) Purpose: discuss use of Ra as a tracer for estimating water contents of magmas.

Methods: ionization chamber.

Results: Ra content in these volcanic gases ranges from 120 to 170pC/l. Information on the distribution coefficient of Ra between magma and vapor is needed before Ra can be used as a tracer to calculate the amount of water released from a magma. Data indicates that the magma erupted at the study site contained only 0.75% (wt.) of water.

11 . A) Gen. Cat.--Behavior of trace elements in geomedia <u>or</u> Element migration

B) Brown, D. A.; Phillips, R. E.; Ashlock, L. O., Fuqua, B. D., 1968, Effect of Al^{3+} and H^{+} upon the simultaneous diffusion of ^{85}Sr and ^{86}Rb in kaolinite clay: Clays and Clay Minerals, v. 16, no. 1, p. 137-146.

C) <u>Purpose</u>: extend the present knowledge of the role of Al^{3+} and H^{+} in soil chemistry and measure diffusion of ^{86}Rb and ^{85}Sr in kaolinitic clay.

<u>Methods</u>: gamma counting.

<u>Results</u>: Rb diffusion was not affected by variation in Al content from 12 to 52%; Sr diffusion significantly increased over this range as Al content increased. The Rb ion had a greater activation energy than Sr (4.8 to 3.6 kcal/mole).

12 . A) Gen. Cat.--Element distribution

B) Korzhinskii, 1968, The theory of metasomatic zoning: Mineralium Deposita, v. 3, no. 3, p. 222-231.

C) Purpose: to discuss the theory of metasomatic zoning.

Methods: thermodynamic analyses

Results: the author discusses the mathematical model of the "outstripping wave of acid components" in relation to the "acid filtration effect." The passage of this acidity wave causes the acid leaching of metals out of rocks and their subsequent concentrated redeposition in veins.

13 . A) Gen. Cat.--Element migration

B) Sakonoue, M.; Yoneda, S.; Ōnishi, K.; Koyama, K.; Komura, K.; Nakanishi, T., 1968, Alpha radioactive nuclides of uranium, proactinium and thorium in uranium deposits: Geochemical Journal, v. 2, no. 2, p. 71-86.

C) Purpose: to report the results of using a stepwise method for quantitative determination of radionuclides in uranium deposits in Japan.

Methods: beta counting, alpha ray spectrometry, chemical analyses (XRF)

Results: in an ore body of Ningyō-Toge Mine, Okayama, Japan, the relationship between the uranium isotopes and their daughter nuclides indicates an extensive migration of uranium. The migration was also verified by the high radium and proactinium contents of a manganese nodule sample.

14. A) Gen. Cat.--Element distribution

B) Bjørlykke, K.; Brunfelt, A. O., 1970, Autoradiography of neutron-activated rock slabs: Chem. Geol., v. 6, p. 233-237.

C) Purpose: to demonstrate an autoradiographic technique, in macro-scale, with applications to polished neutron activated rock slabs.

Methods: neutron activation, autoradiography.

Results: autoradiography of neutron-activated rock reveals a clear and distinct picture of the distribution of induced radioactivity. As many radionuclides are formed by thermal neutron activation, it is difficult to evaluate quantitatively the contribution from each element. In samples with well known elemental composition autoradiographic pictures after thermal neutron activation can provide more detailed information on the distribution of certain elements and reveal structures which are otherwise difficult to obtain.

15 . A)Gen. Cat.--Behavior of trace elements in geomedia

B) Cosgrove, M. E., 1970, Iodine in the bituminous Kimmeridge Shales of the Dorset Coast, England: Geochimica et Cosmochimica Acta, v. 34, no. 7, p. 830-836.

C) Purpose: investigate the high I content of an organic-rich shale.

Methods: XRF, wet chemical methods.

Results: both I and Br correlate strongly with the presence of organic carbon, suggesting that the burial of marine plants in the sediment is responsible for I anomalies. Average I = 17ppm and reach 30 ppm, in the shale fraction; Kimmeridge "Coal" contains up to 72 ppm.

16 . A) Gen. Cat.—Element mobility

B) Mantei, E.; Bolter, E.; Shaieb, Z. A., 1970, Distribution of gold, silver, copper, lead, and zinc in the productive Marysville stock, Montana: Mineralium Deposita, v. 5, no. 2, p. 184-190.

C) Purpose: to investigate the mobility of metals in igneous rocks.

Methods: chemical analyses (neutron activation, atomic absorption)

Results: in the vicinity of known gold veins, anomalous values for gold and silver were found in both types of bedrock. Anomalies for the base metals were much less pronounced. The results indicate that systematic analyses of igneous bodies could be useful in exploration for hydrothermal ore deposits.

17 . A) Gen. Cat.--Behavior of trace elements in geomedia or Hydrothermal alteration

B) Aktanov, M. T., 1971, Behavior of tin in postmagmatic alteration of granitoids of southern Tien Shan (southern Kirghiziya): Geochemistry International, v. 8, no. 3, p. 367-370.

C) Purpose: study behavior of tin in order to gain information on sources of ores.

Methods: petrography, microprobe.

Results: high concentrations of Sn, B, and F in griesenized granites is due to redistribution by postmagmatic solutions. Hydrothermal alteration results in release of Sn from biotite, and , later, its precipitation as cassiterite. There is a good correlation between Sn and B contents in altered granites, but none in pristine granite.

18 . A) Gen. Cat.--Element mobility, U and Th

B) Rosholt, J. N.; Prijana ; Noble, D. C., 1971, Mobility of uranium and thorium in glassy and crystallized silicic volcanic rocks: Economic Geology, v. 66, no. 7, p. 1061-1069.

C) Purpose: to present data on uranium, thorium, and proactinium contents of nonhydrated and hydrated glassy volcanic rocks and the crystallized equivalents of these glasses.

Methods: petrography, chemical analyses.

Results: analyses of hydrated and nonhydrated glass pairs from three welded ashflow units and four lava flows show that the uranium and thorium contents of hydrated glass, when corrected for water hydration, are nearly identical to those of the parent nonhydrated glass. This indicates that no measurable quantities of uranium or thorium were removed from or added to the glass during or after hydration. The uranium content of nine crystallized specimens, however, is only 20 to 70% of that in glasses from the same unit. These differences reflect a loss of uranium from the crystallized material by some combination of a) distillation as the volatile fluoride during cooling and crytallization and b) ground water leaching after cooling.

19. A) Gen. Cat.--Behavior of trace elements in geomedia <u>or</u> Properties of bedded salts.

B) Schock, H. H.; Puchelt, H., 1971, Rubidium and cesium distribution in salt minerals - I. Experimental investigations: Geochimica et Cosmochimica Acta, v. 35, no. 3, p. 307-317.

C) <u>Purpose</u>: investigate the distribution of Rb and Cs between aqueous solution and single crystals of salt minerals.

<u>Methods</u>: gamma spectrometry.

<u>Results</u>: distribution ratio D is defined as:

$$D = \frac{\dfrac{\text{trace element}}{\text{carrier element (solid)}}}{\dfrac{\text{trace element}}{\text{carrier element (solution)}}}$$

In all cases $D < 1$, except for Rb in carnallite. Incorporation of Rb and Cs in carnallite was found to decrease with increasing T. Increasing Mg in solution also inhibits incorporation of these 2 alkalis.

20. A) Gen. Cat.--Element mobility

B) Wodzicki, A. , 1971, Migration of trace elements during contact metamorphism in the Santa Rosa Range, Nevada, and its bearing on the origin of ore deposits associated with granitic intrusions: Mineralium Deposita, v. 6, no. 1, p. 49-64.

C) Purpose: to test the importance of element exchange by determining the distribution of B, Li, Sn, Pb, Cu, Zn, Ni, Mn, Cr, V, and Ti in granitic intrusions and rocks of the Santa Rosa Range.

Methods: chemical analyses (emission spectrography, microphotometry)

Results: Be, Li, Sn, Pb, and in some instances Cu and Zn diffused from the country rocks into the magmas, suggesting that such a process may enhance the potential of a magma as a source of epigenetic ore deposits.

21 . A) Gen. Cat.--Element mobility, Mo.

B) Haffty, J.; Noble, D. C., 1972, Release and migration of molybdenum during the primary crystallization of peralkaline silicic volcanic rocks: Economic Geology, v. 76, no. 6, p. 768-775.

C) Purpose: to compare glassy and primarily crystallized silicic volcanic rocks from the same units, and note which elements are lost during crystallization.

Methods: chemical analyses (optical emission spectrography)

Results: in the rocks studied, Be, Nb, and Sn contents do not appear to have been appreciably affected by crystallization, perhaps because of the peralkaline character of the melts. Molybdenum presumably was removed by water- and halogen-rich vapors evolved during crystallization. Because of the high mobility of Mo, the average contents of this element in sialic igneous rocks probably are less than the Mo contents of the parent magmas.

22 . A) Gen. Cat.--Element mobility, gold

B) Keays, R. R.; Kirkland, M. C., 1972, Hydrothermal mobilization of gold from copper-nickel sulfides and ore genesis at the Thomson River copper mine, Victoria, Australia: Economic Geology, v. 67, no. 8, p. 1263-1275.

C) Purpose: to study the hydrothermal mobilization of gold at the Thomson River copper mine.

Methods: petrography, electron microprobe, SEM, chemical analyses (XRF, AA, NAA).

Results: the ore body occurs in a small dike. The dike (a hornblendite) has been extensively sheared, faulted, and hydrothermally altered. Alteration and carbonatization are most intense in the sheared sections of the dike. Cu, Pd, Ir, Au, and to a lesser extent Co and Ni in the main portion of the dike have migrated from sheared and altered rocks into the segregated sulfides trapped along the footwall of the dike. The greatest redistribution is shown by Au.

23 . A) Gen. Cat.—Element distribution, REE; vein deposits, REE, Th

B) Staatz, M. H.; Shaw, V. E.; Wahlberg, J. S., 1972, Occurrence and distribution of rare earths in the Lemhi Pass thorium veins, Idaho and Montana: Economic Geology, v. 67, no. 1, p. 72-82.

C) Purpose: to study the occurrence and distribution of rare earth elements in the Lemhi Pass thorium veins.

Methods: chemical analyses (XRF).

Results: total rare-earth oxide content of 31 samples from 21 veins in the area ranges from .073 to 2.24 percent. Rare earths and thorium commonly occur together in the same minerals, though in different proportions. The three most common of these minerals are thorite, monazite, and brookite. Some thorium is contained in goethite. Although the rare earths and thorium occur in the same minerals, the amount of rare earth found in the vein has little relation to the amount of thorium. Total rare-earth-oxide to thorium ratios in the 31 analyses range from .05 to 9.2.

24. A) Gen. Cat.--Element distribution

B) Davis, J. D.; Guilbert, J. M., 1973, Distribution of the radioelements potassium, uranium, and thorium in selected porphyry copper deposits: Economic Geology, v. 68, no. 2, p. 145-160.

C) Purpose: to study the overall and relative distributions of potassium, uranium, and thorium in selected deposits, to evaluate such an approach for mineral exploration, and to permit consideration of the physical geochemistry of the radioelements involved.

Methods: radiometric surveys, chemical analyses.

Results: uranium is concentrated either centrally or peripherally, apparently depending on local factors affecting magma crystallization, hydrothermal activity, and supergene effects. Potassium at each mine is enriched as much as twice over similar barren intrusions, while uranium is irregularly enriched. The intensity of thorium radiation is less distinctly zoned. The zonations observed agree well with established geochemical behavior for these elements and with presently accepted alteration models.

25. A) Gen. Cat.--Element exchange

B) Devine, S. B.; Ferrel, R. E., Jr., and Billings, G. K., 1973, The significance of ion exchange to interstitial solutions in clayey sediments: Chem. Geol., v. 12, p. 219-228.

C) Purpose: to examine the theoretical basis for a method of defining in situ interstitial solutions in clayey unconsolidated sediments.

Methods: literature review.

Results: the ion population in interstitial solutions in clayey sediments is distributed by Donnan chemical potential forces between inner and outer (micellar and intermicellar respectively) solutions around clay mineral particles. Efforts to distinguish inner and outer solutions in marine clayey sediments should be made, since these solutions may yield information on the chemical evolution of such sediments. The relationship of solutions extracted by squeezing to Donnan equilibrium remains relatively untested.

26 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Koide, M.; Bruland, K. W.; Goldberg, E. D., 1973, Th-228/Th-232 and Pb-210 geochronologies in marine and lake sediments: Geochimica et Cosmochimica Acta, v. 37, no. 5, p. 1171-1187.

C) Purpose: gain insights into geochemistry and uses of Th and Pb.

Methods: alpha spectroscopy, chemical methods.

Results: there is an excess of ^{228}Th in the sediment, relative to parent isotopes. Apparently, both Th and Ra have very short residence times in the water. Ra may be transferred to sediment by complexation by organic compounds. ^{228}Th/^{232}Th may be a valuable geochronologic tool for time spans on the order of 10's of years.

27 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Price, N. B.; Calvert, S. E., 1973, The geochemistry of iodine in oxidized and reduced recent marine sediments: Geochimica et Cosmochimica Acta, v. 37, no. 9, p. 2149-2158.

C) Purpose: examine difference in behavior of I due to oxidation state.

Methods: X-ray emission spectrometry.

Results: I contents range from 96 to 1990 ppm. I/C shows a smooth trend, decreasing from edge of shelf shoreward, correlating with oxidizing to reducing conditions. I/C is more than an order of magnitude higher in oxidizing as opposed to reducing conditions. High I content in oxidized sediments is due to uptake of I by plankton on the sea bed.

28 . A) Gen. Cat.--chemical halos

B) Bailey, G. B.; McCormick, G. R., 1974, Chemical halos as guides to lode deposit ore in the Park City District, Utah: Economic Geology, v. 69, no. 3, p. 377-382.

C) Purpose: to identify and define possible chemical and mineralogical halos around veins which might be useful as aids in exploration for new vein deposits.

Methods: petrography, chemical analyses (AA).

Results: petrographic study of selected samples showed no detectable mineralogical halos, but chemical halos of Ag, Cu, Mn, Pb, and Zn were found, and they enlarge the target for lode deposit exploration by a factor of more than ten.

29 . A) Gen. Cat.--Element migration

B) Magara, K., 1974, Compaction, ion filtration, and osmosis in shale and their significance in primary migration: American Association of Petroleum Geologists Bulletin, v. 58, no. 2, p. 283-290.

C) Purpose: to quantify ion filtration effect and discuss mechanisms of compaction, ion filtration and osmosis in shales.

Methods: a literature review.

Results:

1) salinity increases as porosity decreases since ions are sorbed by shales as water is expelled.
2) Shale is an effective, but not perfect, ionic filter: salinity of expelled H_2O = 1/3 original salinity.
3) Ion filtration efficiency can be evaluated using normal-salinity trend and shale-porosity trend. High efficiency should result in rapid increase in salinity with depth.
4) Ion filtration does not fully account for salinity in undercompacted zones
5) Porosity in shale usually decreases toward sand bodies.

30. A) Gen. Cat.--Migration in geomedia

B) Pandey, G. N.; Rasin-Tek, M.; Katz, D. L.; 1974, Diffusion of fluids through porous media with implications in petroleum geology: American Association of Petroleum Geologists Bulletin, v. 58, no. 2, p. 291-303.

C) Purpose: characterize diffusion of gases through geomedia.

Methods: mass spectrometer.

Results: effective diffusivity increases with increasing permeability and permeability-porosity product. Increases in pressure or a positive change in pressure increase gas flux; a negative change in pressure decreases gas flux.

31. A) Gen. Cat.--Zoning, mineralogical

B) Williams, K. L., 1974, Compositions of sphalerites from the zoned hydrothermal lead-zinc deposits of Zeehan, Tasmania: Economic Geology, v. 69, no. 5, p. 657-672.

C) Purpose: to summarize the results of microprobe analyses of sphalerites from 50 localities in the sulfide-bearing zones at Zeehan.

Methods: petrography, electron microprobe.

Results: observed sphalerite compositions support the concept of lower FeS contents of sphalerites crytallizing at low temperatures in equilibrium with sulfur-rich iron sulfide assemblages. Furthermore, their zonal variation also suggests that FeS activity late in the Zeehan paragenesis varied systematically with at least one of the parameters that determined the mineralogical zoning.

32 .A) Gen. Cat.--Behavior of trace elements in geomedia <u>or</u> Alteration studies

B) Andreyev, M. I.; Chernyayev, A. M., 1975, Migrational capacity of metals in the supergene zone of sulfide deposits: Geochemistry International, v. 12, no. 6, p. 84-89.

C) <u>Purpose</u>: examine mobility of elements during supergene processes.

<u>Methods</u>: literature review, thermodynamic analysis.

<u>Results</u>: the theoretical mobility series, based on thermodynamic calculations, is: $Mn^{2+} \geq Fe^{2+} \geq Cd^{2+} \geq Zn^{2+} \geq Pb^{2+} \geq Ni^{2+} \geq Cu^{2+}$. Variation from this series is due to geologic and geochemical conditions that are specific to the region under investigation. Most methods for calculating element mobilities are satisfactory for a single example.

33 . A) Gen. Cat.—Behavior of trace elements in geomedia

B) Robbins, J. A.; Edgington, D. N., 1975, Determination of recent sedimentation rates in Lake Michigan using Pb-210 and Cs-137: Geochimica et Cosmochimica Acta, v. 39, no. 3, p. 285-304.

C) Purpose: report on the uses of ^{210}Pb and ^{137}Cs in determining sedimentation rates.

Methods: alpha and beta counting.

Results: mobility of both radionuclides in the sediment is small. Modern sedimentation rates are in close agreement with those estimated for the last 7000 years. Transport of ^{210}Pb and ^{137}Cs into the basin probably involves attachment to settling particles. The study shows that the use of ^{210}Pb for this purpose is a valid and powerful technique.

34 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Brookins, D. G., 1976, Shale as a repository for radioactive waste: the evidence from Oklo: Environmental Geology, v. 1, no. 5, p. 255-259.

C) Purpose: point out the desirable qualities of a shale as a repository rock.

Methods: literature review.

Results: most fission products, with the exceptions of Xe, Kr, and I, have been retained or only slightly mobilized at Oklo. Migration may not have begun until 25 million years after the reactor shut down. Retention of elements in this apparently unfavorable environment (a shale infilled into a fracture system in organo-argillaceous sandstone) indicates that shale should be considered as a repository for radioactive waste.

35 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Friesen, L. J.; Adams, J. A. S., 1976, Low pressure radon diffusion: a laboratory study and its implications for lunar venting: Geochimica et Cosmochimica Acta, v. 40, no. 4, p. 375-380.

C) Purpose: report results of a study of radon diffusion through soil columns.

Methods: alpha counting.

Results: heats of adsorption of radon on the materials studied clustered around 8-9 kcal/mole. This implies that radon migration in lunar soils is accomplished by traveling with other gases during venting events.

36. A) Gen. Cat.--Uranium mobility, ground-water

B) Grandstaff, D. E., 1976, A kinetic study of the dissolution of uraninite: Economic Geology, v. 71, no. 8, p. 1493-1506.

C) Purpose: to mathematically describe the kinetics of uraninite dissolution in water.

Methods: chemical analyses, electron microprobe, kinetic studies.

Results: the kinetics of uraninite dissolution in water may be summarized by the equation:

$$R = \frac{-d(\mathrm{uran})}{dt} = 10^{20.25}\,(SS)\,(RF)^{-1}\,(10^{-3.33-10.8\,NOC})(a\sum CO_2)(D.O.)(aH^{+})\,\exp(-7045/T)\,\mathrm{day}^{-1}$$

where R is the rate of the dissolution reaction, SS is the specific surface area ($cm^2 gm^{-1}$), RF is an organic retardation factor, NOC is the mole fraction of non-uranium cations in the uraninite, D.O. is the dissolved oxygen content of the water (ppm), $\sum CO_2$ is the total dissolved carbonate, and T is the absolute temperature.

37 . A) Gen. Cat.--Element zoning, alteration, carbonates

B) James, L. P., 1976, Zoned alteration in limestone at porphyry copper deposits, Ely, Nevada: Economic Geology, v. 71, no. 2, p. 488-512.

C) Purpose: to discuss the geology and mineralogy of the portions of the Ely deposits exposed in 1968-1971 (especially the alteration in limestones) and to present a model of mineral zoning there.

Methods: geologic mapping, petrography, chemical analyses (solution spectrographic technique, AA), XRD.

Results: the relationshipsbetween the different alteration types described above can be used as a model to aid in determining the prefaulting shape of the Ely porphyry copper system. Several bodies of mineralized porphyry and limestone apparently were once cupola-like features above the large unmineralized pluton. Chemical data suggest that these porphyry bodies could have provided sufficient iron to form the adjacent tactite assemblages, but that copper, sulfur, and some other elements were derived from elsewhere.

38. A) Gen. Cat.--element mobility, alteration

B) Olade, M. A.; Fletcher, W. K., 1976, Trace element geochemistry of the Highland Valley and Guichon Creek Batholith in relation to porphyry copper mineralization: Economic Geology, v. 71, no. 4, p. 733-748.

C) Purpose: to present a general account of studies on trace element distribution in bedrock around four major porphyry copper deposits in the Highland Valley (Bethlehem-JA, Valley Copper, Lornex, and Highmont) district of the Guichon Creek batholith in relation to primary lithology and mineralization and associated alteration processes.

Methods: chemical analyses (XRF, AA), petrography.

Results: Bedrock geochemical patterns in proximity to porphyry copper deposits in the Highland Valley, British Columbia, can be related to (1) primary lithology - Ti, V, Zn, Mn, and Co; (2) hydrothermal alteration - Ba, Rb, Sr and to a lesser extent Mn and Zn; and (3) mineralization - Cu, S, Mo, B, and in some cases Hg and Cl.

39 . A) Gen. Cat.--Element mobility

B) Condie, K. C.; Viljoen, M. J.; Kable, E. J. D., 1977, Effects of alteration on element distributions in Archean tholeiites from the Barbeton greenstone belt, South Africa: Contributions to Mineralogy and Petrology, v. 64, no. 1, p, 75-89.

C) Purpose: to report the results of a geochemical study of progressive epidotization and carbonization in tholeiites from the Barbeton greenstone belt.

Methods: petrography, chemical analyses (XRF, neutron activation)

Results: Au, As, Sb, Sr, Fe^{3+}, Ca, Br, Ga, and U are enriched and H_2O, Na, Mg, Fe^{2+}, K, Rb, Ba, Si, Ti, P, Ni, Cs, Zn, Nb, Cu, Zr, and Co are depleted during epidotization. CO_2, H_2O, Fe^{2+}, Ti, Zn, Y, Nb, Ga, Ta, and light REE are enriched and Na, Sr, Cr, Ba, Fe^{3+}, Ca, Cs, Sb, Au, Mn and U are depleted during carbonization-chloritization. The element least affected by epidotization are Hf, Ta, Sc, Cr, Th, and REE, those least affected by carbonization-chloritization are Hf, Ni, Co, Zr, Th, and heavy REE.

40. A) Gen. Cat.--Behavior of trace elements in geomedia or Sorption studies

B) Hem, J. D., 1977, Reactions of metal ions at surfaces of hydrous iron oxide: Geochimica et Cosmochimica Acta, v. 41, no. 4, p. 527-538.

C) Purpose: review the thermodynamics of substrate/solute reactions.

Methods: calculations based on published data.

Results: $Fe(OH)_3$ and Fe^{2+} can decrease concentrations of Cr, Cu, and Ag in water by reduction. V and Mo concentration can be controlled by precipitation as ferrous vanadate or molybdate. Mn can be oxidized through Fe redox reactions. Solubilities below 10^{-9}M can be attained for divalent metals at neutral pH's due to sorption on ferric hydroxide. As is influenced by Fe only at low pH.

41 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) James, R. O.; MacNaughton, M. G., 1977, The adsorption of aqueous heavy metals on inorganic minerals: Geochimica et Cosmochimica Acta, v. 41, no. 11, p. 1549-1555.

C) Purpose: use Zn to demonstrate the behavior of hydrosoluble metals in colloidal dispersions.

Methods: AAS, scintillation counting.

Results: surface chemical controls can account for the removal of heavy metals, particularly Zn(II), from solutions that are undersaturated with respect to the hydroxide, oxide, or other controlling phases. Two models may account for this: 1) electrical double layer models, or, 2) ion exchange models that do not consider the structure of the interface.

42 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Loubet, M.; Allegre, C. J.; 1977, Behavior of the rare earth elements in the Oklo natural reactor: Geochimica et Cosmochimica Acta, v. 41, no. 11, p. 1539-1548.

C) Purpose: analyze REE data to determine the mobility of the elements at Oklo.

Methods: mass spectrometry.

Results: all elements studied, except Ba, have abnormal compositions. Data indicate that REE are a mixture of fission products and naturally occurring isotopes. Calculations suggest migration of HREE relative to LREE to outside the reactor zone, although no migration took place during the reaction. HREE mobility may be a result of complexing with carbonate or fluoride.

43. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Schell, W. R., 1977, Concentrations, physico-chemical states and mean residence times of ^{210}Pb and ^{210}Po in marine and estuarine waters: Geochimica et Cosmochimica Acta, v. 41, no. 8, p. 1019-1031.

C) Purpose: present data on properties of ^{210}Pb and ^{210}Po in water.

Methods: Si-surface barrier detection, beta counting.

Results: ^{210}Pb increases with depth in the upper 150 m of water, ^{210}Pb can be associated with either the soluble (colloidal) fraction or with ^{210}Po and the particulate ($\geq 0.3 \mu m$) fraction. Mean residence times vary from 58 days to 2.6 years. ^{210}Pb and ^{210}Po can be used to trace particle removal rates from the upper layers of seawater.

44 . A) Gen. Cat.--Element mobility

B) Schrader, E., 1977, Relationships between uranium and trace metal concentrations in volcanic rocks from Nevada: Economic Geology, v. 72, no. 1, p. 104-107.

C) Purpose: to see if trace metals can be an effective prospecting guide for uranium deposits.

Methods: chemical analyses (AA), XRD, petrography.

Results: data shows that trace metals that commonly accompany sandstone-type uranium deposits are also seen to occur significantly with uranium in possible source rocks for such an ore. It can also be inferred that anomalous concentrations of copper and cobalt in rhyolites altered by hydrothermal action could be used as a practical geochemical prospecting tool for uranium in a volcanic environment. Thus, correlations of the content of certain trace elements with uranium concentration in volcanic rocks may be usefully applied as a prospecting tool.

45 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Shukolyukov, Y. A.; Min, T. W., 1977, Anomalies in the isotopic composition of xenon and krypton from the Oklo deposit (Gabon, Africa): Geochemistry International, v. 14, no. 6, p. 1-13.

C) Purpose: present results of a detailed study of isotopic anomalies in Xe and Kr at Oklo.

Methods: mass spectrometry.

Results: correlation of isotope ratios points to a common source for the excess Kr and Xe isotopes. The anomalies cannot be explained by fission of ^{239}Pu by thermal neutrons, fission of ^{238}U by fast neutrons, or spontaneous fission of ^{238}U. Further, no known heavy element produces fission products of mass numbers 129-136 in the proportions observed. Thus, no hypothesis can be presented to explain the observations. It is necessary to determine which particular mineral is the carrier of anomalous Xe and Kr.

46 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Shukolyukov, Y. A.; Minh, D. V., 1977, Anomalous Xe and Kr isotope compositions in the Oklo deposit, Gabon: Geochemistry International, v. 14, no. 6, p. 99-108.

C) Purpose: examine anomalies in Xe and Kr isotopic ratios at Oklo.

Methods: mass spectrometry.

Results: anomalous Xe ratios are found only in samples that contain no uraninite. These ratios appear to represent mixing of normal fission-product Xe from ^{235}U and anomalous Xe from another mineral phase. Anomalous Xe (Xe_a) is carried by a mineral with a specific gravity of 3-4; its release rate reaches a maximum at 800°C. Data indicate that Xe_a is derived from a progenitor arising in the fission reaction whose lifetime is sufficient to allow migration from uraninite and accumulation in another phase.

47 . A) Gen. Cat.--Element distribution

B) Urabe, T., 1977, Partition of cadmium and manganese between coexisting spalerite and galena from some Japanese epithermal deposits: Mineralium Deposita, v. 12, no. 3, p. 319-330.

C) Purpose: to use minor element geothermometry for a study on some Japanese epithermal deposits.

Methods: chemical analyses (AA), electron microprobe

Results: the temperatures, evaluated from the partition of cadmium between coexisting spalerite and galena, are consistent within a total range of 150°C at maximum within an individual deposit. No systematic change with depth can be observed at the Shoko-hi vein, Hosokura mine, and Hompi vein, Yatani mine.

48. A) Gen. Cat.--Behavior of trace elements in geomedia.

B) Wong, G. T. F.; Brewer, P. G., 1977, The marine chemistry of iodine in anoxic basins: Geochimica et Cosmochimica Acta, v. 41, no. 1, p. 151-159.

C) Purpose: report on the distribution of I in 2 anoxic basins.

Methods: chemical methods, INAA.

Results: Iodate (IO_3^-) is the dominant species in normal seawater; concentration increases with depth. Iodide (I^-) concentration decreases with depth. This trend is reversed in anoxic basins. Iodine/salinity is lowest in surface waters, suggesting depletion by organisms. This ratio reaches a maximum just above the oxygen-sulfide boundary.

49. A) Gen. Cat.—element mobility

B) Brookins, D. G., 1978, Retention of transuranic and actinide elements and bismuth at the Oklo natural reactor, Gabon: application of Eh-pH diagrams: Chemical Geology, v. 23, no. 4, p. 309-323.

C) Purpose: to discuss Pu and other transuranic elements plus Bi in terms of Eh-pH diagrams.

Methods: thermodynamic analyses

Results: Eh-pH diagrams for all species of importance indicate the following: Po is retained as the native metal in the Eh-pH range of interest, whereas Pu and Np are retained as PuO_2 and NpO_2 respectively. Am is probably retained as $Am(OH)_3$ or as an $(Eu,Am)_2(CO_3)_3$ species. The field of Bi_2S_3 is wide enough to prevent migration even under slightly oxidizing conditions. Collectively, these data argue for the retention of Pu, Am, Np, U, Po and Bi at Oklo and suggest that geologic sites elsewhere should be suitable for waste disposal.

50. A) Gen. Cat.--Element mobility

B) Brookins, D. G., 1978, Eh-pH diagrams for elements from Z=40 to Z=52: application to the Oklo natural reactor, Gabon: Chemical Geology, v. 23, no. 4, p. 325-342.

C) Purpose: to construct Eh-pH diagrams for the elements from Z=40 (Zn) to Z=52 (Te) in order to comment on migration/retention of these elements at Oklo.

Methods: thermodynamic analyses.

Results: based on Eh-pH diagrams, migration (to what degree is uncertain) of Mo and Cd is predicted whereas retention of Y, Zr, Tc, Ru, Rh, Pd, Ag, and Te is also predicted. Although data for fissiogenic amounts of some of these elements are lacking, where such data are available the agreement between predicted migration/retention based on the Eh-pH diagrams and actual measurements is excellent.

51. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Edwards, A. C., 1978, Tectonic implications of the immobile trace-element geochemistry of mafic rocks bounding the Wonaminta Block: Australian Journal of Earth Sciences, v. 25, pt. 8, p. 459-465.

C) Purpose: assess the petrologic affinities of the mafic rocks of Wonaminta.

Methods: petrography, literature review.

Results: low grade metamorphism has not influenced the distribution of P_2O_5, Zr, Y, and Nb. Ti has been mobilized from oxides but not silicates. Use of trace element can allow reconstruction of tectonic settings.

52 . A) Gen. Cat.--Element mobility

B) Furnes, H., 1978, Element mobility during palagonization of a subglacial hyaloclastite in Iceland: Chemical Geology, v. 22, no. 3, p. 249-264.

C) Purpose: to study the relationship of the chemical composition of palagonite relative to its parent sideromelane, and the chemical environment during alteration.

Methods: petrography, XRD, chemical analyses (XRF, AA), specific gravity measurements.

Results: except H_2O (H_2O^+ and H_2O^-) and Fe_2O_3 which are gained during palagonization, all the other major oxides are depleted relative to the parent sideromelane, and the degree of depletion can be positively correlated with the H_2O^+ content of palagonite. Trace elements behave differently upon alteration. Some, e. g., Cr, Co, Cu, and Ni, are consistently enriched in palagonite relative to the parent, whereas V, Nb, Zr, Ce, Nd, and La all show consistent depletion. Zn, Rb, Sr, Y and Ba show variable trends, the last element being mostly depleted. Both Rb and Sr show a wide scatter. The trace elements that are least affected (less than average 20%) by alteration are Zn, Ni, Y, Ba, and Nb.

53 . A) Gen. Cat.--Element mobility

B) Humphris, S.E.; Morrison, M. A.; Thompson, R. N., 1978, Influence of rock crystallization history upon subsequent lanthanide mobility during hydrothermal alteration of basalts: Chemical Geology, v. 23, no. 2, p. 125-137.

C) Purpose: to study the mobility of the REE during hydrothermal alteration.

Methods: petrography, chemical analyses (unspecified)

Results: it is postulated that the main control on potential lanthanide mobility is the igneous crystallization history of the individual lavas, because this affects the sites of concentration, and hence availability of the REE during hydrothermal alteration.

54. A) Gen. Cat.--Element mobility

B) Ludwig, K. R., 1978, Uranium-daughter migration and U/Pb isotope apparent ages of uranium ores, Shirley Basin, Wyoming: Economic Geology, v. 73, no. 1, p. 29-49.

C) Purpose: main goals were to : 1) evaluate the roles of inherited radiogenic lead and uranium-daughter loss as causes of the typically scattered and discordant U-Pb isotopic ages of young uranium ores, and 2) develop, if possible, methods for determining the true ages of mineralization from such ores.

Methods: U-Pb dating, chemical analyses.

Results: uranium-daughter migration for both permeable and nearly impermeable ores is extremely complex, both within and beyond the boundaries of total ore samples.

55. A) Gen. Cat.--Behavior of trace elements in geomedia <u>or</u> Properties of bedded salts.

B) Osichkina, R. G., 1978, Rb and Cs levels in Late Jurassic salt beds in southern Central Asia in relation to conditions of formation: Geochemistry International, v. 15, no. 3, p. 168-173.

C) <u>Purpose</u>: examine causes of elevated levels of Rb and Cs in bedded salts.

<u>Methods</u>: none discussed.

<u>Results</u>: post depositional changes are identified as the causes for elevated levels of Rb and Cs in carnallite and sylvite, particularly recrystallization of carnallite. Secondary carnallite contains 10 times as much Rb as primary carnallite. Subsequently, incongruent dissolution of secondary carnallite further concentrates Cs and Rb in the newly formed sylvite phase.

56 . A) Gen. Cat.--Element distribution

B) Spitz, G.; Darling, R., 1978, Major and minor element lithogeochemical anomalies surrounding the Louvem copper deposit, Val d'Or Quebec: Canadian Journal of Earth Sciences, v. 15, no. 7, p. 1161-1169.

C) Purpose: to study the lithogeochemical anomalies surrounding the Louvem copper deposit.

Methods: chemical analyses (AA, XRF)

Results: The Louvem copper deposit is included in a layer of altered metavolcanic rocks that are richer in Fe and S and poorer in Na_2O, CaO, and CO_2 than adjacent unaltered metavolcanic rocks. The chemical zoning of the wallrock alteration around the Louvem copper deposit suggests that it was formed by hydrothermal solutions that travelled eastwards along a permeable fragmental layer within the volcanic pile.

57 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Asikainen, M.; Kahlos, H., 1979, Anomalously high concentrations of uranium, radium, and radon in water from drilled wells in the Helsinki region: Geochimica et Cosmochimica Acta, v. 43, no. 10, p. 1681-1686.

C) Purpose: summarize results of analyses of 308 drilled wells near Helsinki, Finland.

Methods: gamma spectrometry, scintillation counting, chemical methods.

Results: in 14 of 308 wells, U content exceeded 1000 μg/liter. in one well it reached 14,870 μg/liter. ^{226}Ra ranged from 0.1 to 256 pCi/liter, and ^{222}Rn ranged from 100 to 880,000 pCi/liter. Shallow wells showed no anomalous radioactivity. ^{234}U - ^{238}U disequilibrium was common. Data seems to indicate that high radioactivity is caused by fissure U deposits.

58 . A) Gen. Cat--Element mobility

B) Davies, J. F.; Grant, R. W. E. ; Whitehead, R. E. S., 1979, Immobile trace elements and Archaen volcanic stratigraphy in the Timmons mining area, Ontario: Canadian Journal of Earth Sciences, v. 16, no. 2, p. 305-311.

C) Purpose: to test the use of immobile trace elements as a tool for deciphering Archean volcanic stratigraphy and structure.

Methods: chemical analyses, petrography.

Results: the trace elements Y, Zn, TiO_2, and Cr remain relatively immobile, and trace element studies may be useful in confirming the structure and stratigraphy interpreted from field mapping of other complex altered Archean volcanic areas.

59 . A) Gen. Cat.--Element distribution

B) Hudson, T.; Smith, J. G.; Elliott, R. L., 1979, Petrology, composition, and age of intrusive rocks associated with the Quartz Hill molybdenite deposit, southeastern Alaska: Canadian Journal of Earth Sciences, v. 16, no. 9, p. 1805-1822.

C) Purpose: to outline the geologic setting of the Quartz Hill area and to identify the general petrology, composition, and age of intrusive rocks associated with the Quartz Hill deposit.

Methods: geologic mapping, petrography, chemical analyses, K-Ar age determinations.

Results: most striking feature of trace element data is the low concentration of many elements, including the fugitive or volatile elements B, Pb, Sn, and Li.

60 . A) Gen. Cat.--Element distribution

B) Mookherjee, A.; Philip, R., 1979, Distribution of copper, cobalt, and nickel in ores and host rocks, Ingladhal, Karnataka, India: Mineralium Deposita, v. 14, no. 1, p. 33-55.

C) Purpose: to report results of a geochemical investigation of the Ingladhal copper deposit.

Methods: petrography, chemical analyses (AA)

Results: unusually high cobalt contents of metavolcanics and of sulfide minerals in orebodies suggest a consanguinity between ores and rocks. 90% of total nickel, 70% of total cobalt but only 30% of total copper in rocks occur in silicate phases and thus indicate an early separation of copper from cobalt and nickel. Very high trace metal content of orebody pyrite sharply contrasts with very low values in pyrite from adjacent sediments and points to a higher temperature of formation of orebodies.

61 . A) Gen. Cat.--Element mobility, uranium

B) Qidwai, H. A.; Jensen, M. L., 1979, Methodology and exploration for sandstone type uranium deposits: Mineralium Deposita, v. 14, no. 2, p. 137-152.

C) Purpose: to summarize significant relationships of uranium geochemistry in the supergene environments and depositional characteristics of fluvial, deltaic, and lacustrine environments and their influence on exploration.

Methods: literature review

Results: emphasis is on exploration implications. This paper emphasizes depositional characteristics that govern the movement of ground water and localization of favorable sites for uranium precipitation.

62 . A) Gen. Cat.--Element migration

B) Ringwood, A. E.; Kesson, S. E.; Ware, N. G.; Hibberson, W. O.; Major, A., 1979, The SYNROC process: A geochemical approach to nuclear waste immobilization: Geochemical Journal, v. 13, no. 4, p. 141-165.

C) Purpose: to discuss the use of SYNROC as an immobilizer for high-level nuclear wastes.

Methods: experimental petrology, XRD, electron microprobe.

Results: SYNROC phases have structures analogous to natural minerals which have survived a variety of geological conditions for millions of years while retaining certain high-level waste elements in their crystal lattices. This fact, coupled with the exceptional resistance exhibited by SYNROC in accelerated leaching tests, leads to considerable confidence in the long-term stability of SYNROC, and in its capacity to isolate high-level wastes from the biosphere for periods sufficiently long to permit their safe decay.

63 . A) Gen. Cat.--Element mobility, uranium

B) Snelling, A. A.; Dickson, B. L., 1979, Uranium/daughter disequilibrium in the Koongarra uranium deposit, Australia: Mineralium Deposita, v. 14, no. 1, p. 109-118.

C) Purpose: to use results from the study of disequilibrium patterns within and around a vein-type uranium deposit to test a number of hypotheses regarding groundwater movement of uranium and its daughter products.

Methods: chemical analyses (neutron activation), radiometric measurements.

Results: radiometric disequilibria occurs in the Koongara uranium deposit amongst the low grade host wall rocks and in the dispersion fan above the No. 1 orebody. The massive ore zones are at, or close to, equilibrium. No conclusive evidence was found for movement of uranium from depth to the dispersion fan, but redistribution of both uranium and radium is observed at depth within the primary ore zones and the host wall rocks.

64 . A) Gen. Cat.—Element haloes, manganese

B) Stumpfl, E. F., 1979, Manganese haloes surrounding metamorphic stratabound base metal deposits: Mineralium Deposita, v. 14, no. 2, p. 207-217.

C) Purpose: to determine if primary manganese haloes "survive" amphibolite or granulite facies conditions, and if so, how?

Methods: petrography, chemical analyses (XRF), electron microprobe.

Results: primary manganese haloes "survive" medium to high-grade regional metamorphism: stratabound base metal deposits in Namaqualand, N.W. Cape Province (Proterozoic) and in the Eastern Alps (Paleozoic and Mesozoic) reveal an increase in Mn as the ore horizon (and associated BIF) is approached from the hanging wall or the footwall. Electron microprobe analyses show Mn to be preferentially concentrated in garnets.

65 . A) Gen. Cat.--Element mobility

B) Zielinski, R. A., 1979, Uranium mobility during interaction of rhyolitic obsidian, perlite and felsite with alkaline carbonate solution: T = 120°C, P = 210 kg/cm^2: Chemical Geology, v. 27, no. 1/2, p. 47-63.

C) Purpose: to investigate the relative influence of the major parameters affecting the rate of leaching of U from obsidian-perlite-felsite.

Methods: leaching studies.

Results: the rate of U removal from crushed glassy samples increases with decreasing average grain size (surface area). Initial rapid loss of a small component ($\approx$ 2.5%) of the total U from crushed felsite, followed by much slower U loss, reflects variable rates of attack of numerous uranium sites.

66 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Cochran, J.K.; Krishnaswami, S., 1980, Radium, thorium, uranium and ^{210}Pb in deep-sea sediment pore waters from the north equatorial Pacific: American Journal of Science, v. 280, no. 9, p. 849-889.

C) Purpose: interpret radionuclide flux across sediment-water interface.

Methods: α-spectrometry, α- and β- counting.

Results: both Ra and U are mobile in these pore waters. Ra distribution is controlled by bioturbation, diffusion and adsorption. Observed fluxes for ^{220}Ra and ^{228}Ra are comparable to calculated fluxes. Pore water shows enrichment of ^{234}U relative to ^{238}U, but a depletion of total U relative to seawater, indicating that U may be locked up in the sediment. ^{210}Pb is probably the result of ^{222}Rn decay. ^{232}Th data are inconclusive.

67. A) Gen. Cat.--Element mobility

B) Davies, J. F.; Whitehead, R. E. S., 1980, Further immobile element data from altered volcanic rocks, Timmins mining area, Ontario: Canadian Journal of Earth Sciences, v. 17, no. 3, p. 419-423.

C) Purpose: to test the method of using trace elements to identify and correlate altered Archean volcanic rocks.

Methods: chemical analyses

Results: Trace-element data can be used for distinguishing volcanic units and as an aid in correlation regardless of any petrogenetic interpretations.

68 . A) Gen. Cat.--Ion mobility

B) Dowty, E., 1980, Crystal-chemical factors affecting the mobility of ions in minerals: American Mineralogist, v. 65, no. 1 and 2, p. 174-182.

C) Purpose: to use simple concepts of geometry and ionic bonding to rationalize ion-mobility data, explain some "anomalies," and make predictions about relative diffusion rates of ions in oxides and silicate minerals and melts.

Methods: porosity analysis, electrostatic site, energy measurements.

Results: factors of porosity, site energy, and ionic radius are obviously influential in the majority of cases, and can be very useful in the qualitative understanding of relative mobilities of ions.

69. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Ullman, W. J.; Aller, R. C., 1980, Dissolved iodine flux from estuarine sediments and implications for the enrichment of iodine at the sediment-water interface: Geochimica et Cosmochimica Acta, v. 44, no. 8, p. 1177-1184.

C) Purpose: examine diagenetic redistribution processes as they occur near the sediment-water interface.

Methods: Ce-As catalytic method to analyze for I flux, pore water I content, and I production.

Results: data are consistent with the release of I into solution during the anaerobic decay of organic matter. Total I in pore water shows a correlation with concentrations of other decay products such as NH_4^+. Flux estimates calculated from pore water concentrations or dissolved I production rate are higher than that measured at the same site, suggesting the I reacts at or near the sediment-water interface and is taken out of solution.

70. A) Gen. Cat.--Element distribution

B) Whalen, J. B., 1980, Geology and Geochemistry of the molybdenite showings of the Ackley City batholith, south-east Newfoundland: Canadian Journal of Earth Sciences, v. 17, no. 9, p. 1246-1258.

C) Purpose: to obtain a better understanding of the nature and origin of these showings, a study considered important in terms of metallogenic models of the Appalachians, and the genesis of molybdenite deposits in general.

Methods: chemistry, petrography.

Results: aplites and pegmatites, which are spatially related to the south-east contact of the alaskite (the batholith consists of alaskite and K-feldspar megacrystic granite) and have the Molybdenite showings, formed by in situ fractional crystallization of the alskite at shallow depths (1.8 to 3.7 km) to produce a roof-zone complex. Mo is localized in these rocks, which formed from the final residual melt and coexisting vapor phase, and is considered to be closely genetically related to them.

71 . A) Gen. Cat.--Element mobility

B) Zielinski, R. A.; Lindsey, D. A.; Rosholt, J. N., 1980, The distribution and mobility of uranium in glassy and zeolitized tuff, Keg Mountain area, Utah, U.S.A.: Chemical Geology, v. 29, no. 1/2, p. 139-162.

C) Purpose: to model the distribution and mobility of U between glassy tuff and diagenetically altered tuff.

Methods: XRD, chemical analyses (direct-reading spectrographic analyses, delayed-neutron analyses), gamma-ray spectrometry, uranium distribution measurements, uranium decay-series measurements.

Results: the variation of U in the tuff is controlled mainly by its primary abundance in glass and by the relative abundance of non-uraniferous detritus and uraniferous accessory minerals. Alteration of glass to zeolite, even though extensive, caused no large or systematic change in the bulk concentration of U in the tuff.

72 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Asikainen, M., 1981, State of disequilibrium between ^{238}U, ^{234}U, ^{226}Ra, and ^{222}Rn in groundwater from bedrock: Geochimica et Cosmochimica Acta, v. 45, no. 2, p. 201-206.

C) Purpose: study natural radioactivity patterns in groundwater in Finland.

Methods: liquid scintillation counting, titration, alpha spectrometry.

Results: a high state of radioactive disequilibrium exists between members of the U series. $^{238}U/^{226}Ra$ varied from 1-20; $^{238}U/^{222}Ra$ varied from 1-20 x 10^{-4}; $^{234}U/^{238}U$ varied from 0.76 to 4.67. Wells with anomalously high U contents, but unexceptional ^{222}Rn and ^{226}Ra, suggest high mobility of U in these waters. ^{222}Rn is the main contributor to the radioactivity of the water studied.

73 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Asikainen, M., 1981, Radium content and the $^{226}Ra/^{228}Ra$ activity ratio in groundwater from bedrock: Geochimica et Cosmochimica Acta, v. 45, no. 8, p. 1375-1381.

C) Purpose: determine concentrations of Ra isotopes in unusually radioactive water in Finland.

Method: liquid scintillation counting.

Results: amount of ^{228}Ra is independent of the amount of ^{226}Ra; ^{228}Ra content was nearly uniform and $^{226}Ra/^{228}Ra$ thus increased as ^{226}Ra increased. Range for this ratio was 0.3 to 26. Abnormally high ratios suggest that radioactivity anomalies are caused by U deposits and not by common rocks. Samples with low radioactivity had $^{226}Ra/^{228}Ra$ ratios that corresponded to the typical U/Th ratio of granite (which underlies the study area).

74 . A) Gen. Cat.--Element mobility

B) Finlow-Bates, T.; Stumpfl, E. F., 1981, The behavior of so-called immobile elements in hydrothermally altered rocks associated with volcanogenic submarine-exhalative ore deposits: Mineralium Deposita, v. 16, no. 2, p. 319-328.

C) Purpose: to report the results of a study of the so-called immobile elements in five massive sulfide deposits.

Methods: petrography, chemical analyses.

Results: it is shown that while Zr, TiO_2 (and Ce?) are mostly immobile even during intense hydrothermal alteration, Y and particulary Sc and Nb may be extremely mobile. Therefore, of the so-called immobile trace elements, only Zr and TiO_2 may be used with any reliability to identify the degree of magmatic differentiation in a hydrothermally altered rock.

75 . A) Gen. Cat.--Element distribution

B) Fountain, J. C.; Hodge, D. S., 1981, Incorporation of U and Th into a monzonite pluton, Laramie Range, Wyoming: Economic Geology, v. 76, no. 8, p. 2253-2256.

C) Purpose: To investigate the spatial distribution of U and Th to determine the evolution of U and Th in this igneous complex.

Methods: petrography, chemical analyses (neutron activation analyses)

Results: the hypersthene monzonite magma of the Laramie Anorthosite Complex was contaminated by reaction with mafic and pelitic gneisses, and near the western contacts, by granitic gneisses. The contamination resulted in increases in U, Th, and REE abundances within the monzonite and added radiogenic strontium.

76 . A) Gen. Cat.--Element mobility

B) Freer, R., 1981, Diffusion in silicate minerals and glasses: a data digest and guide to the literature: Contributions to Mineralogy and Petrology, v. 76, no. 4, p. 440-454.

C) Purpose: to present a compilation of data for diffusion in silicate minerals and glasses, along with a "working guide" for its use.

Methods: literature search, thermodynamic analyses

Results: published data and experimental conditions are listed in tables, and these are preceded by an outline of diffusion mechanisms, terminology, equations and units, diffusion regimes, factors controlling diffusion rates, measurement techniques, and diffusional behavior .

77 . A) Gen. Cat.--Element distribution

B) Lincoln, T. N., 1981, The redistribution of copper during low-grade metamorphism of the Karmutsen Volcanics, Vancouver Island, British Columbia: Economic Geology, v. 76, no. 8, p. 2147-2161.

C) Purpose: To report the results of a systematic investigation of the distribution of copper and other transition elements in the Karmutsen Volcanics during low-grade metamorphsim.

Methods: petrography, chemical analyses (AA).

Results: evidence presented suggests that copper was substantially redistributed during low-grade metamorphism of the subaerially erupted flows of the Karmutsen Volcanics.

78 . A) Gen. Cat.--Radionuclides, disequilibria

B) Löfvendahl, R.; Holm, E., 1981, Radioactive disequilibria and apparent ages of secondary uranium minerals from Sweden: Lithos, v. 14, no. 3, p. 189-201.

C) Purpose: to examine the degree of radioactive equilibrium and apparent ages of secondary uranium minerals in Sweden.

Methods: alpha spectrometry, petrography.

Results: mineral ages are proportional to the distance below the bedrock surface. Minerals coated on the bedrock surface are usually postglacial with apparent ages below 10000 years. Minerals collected from cracks and fissures 3-100 mm below the bedrock surface give apparent ages from 14000 years to equilibrium ages of more than 300,000 years. Some mineral samples have lost uranium, indicating open system conditions.

79 . A) Gen. Cat.--Radiohaloes

B) Seal, M.; Vance, E. R.; Demayo, B., 1981, Optical spectra of giant radiohaloes in Madagascan biotite: American Mineralogist, v. 66, no. 3 and 4, p. 358-361.

C) Purpose: to study optical spectra of the halo regions and see if any further clues to the origin of the haloes would emerge.

Methods: Mossbauer spectroscopy, electron microprobe, constant acceleration spectroscopy, monochromatic microscope photometer system.

Results: results are consistent with the theory that the bleached haloes formed through the reducing action on ferric iron of atomic hydrogen produced by radiolysis.

8Q A) Gen. Cat.—Element mobility

B) Tieh, T. T.; Ledger, E. B., 1981, Fission track study of uranium in two granites of central Texas: Contributions to Mineralogy and Petrology, v. 76, no. 1, p. 12-16.

C) Purpose: to determine the abundance , distribution, and nature of occurrence of uranium in these granites.

Methods: petrography, fission tracks, delayed neutron counting.

Results: uranium in cores from Precambrian granites of central Texas exhibits four modes of occurrence: 1) in accessory minerals, 2) along grain boundaries, 3) in microfractures, and 4) in quartz and feldspar grains.

81 . A) Gen. Cat.—Element mobility

B) Zielinski,R. A.; Peterman, Z. E.; Stuckless, J. S.; Rosholt, J. N.; Nkomo, I. T., 1981, The chemical and isotopic record of rock-water interaction in the Sherman Granite, Wyoming and Colorado: Contribution to Mineralogy and Petrology, v. 78, no. 3, p. 209-219.

C) Purpose: to describe the effects of rock-water interactions in core samples of petrographically fresh, 1.43 billion year old Sherman Granite.

Methods: petrography, chemical analyses (XRF, AA, isotope dilution, plasma optical-emission spectrometry, delayed neutron analyses) U, Th, Rb, Sr, Pb isotopes

Results: laboratory experiments using freshly crushed Sherman Granite confirm that uranium is leached in preference to elements such as Si, Mg, Ca, and K, and that leachable uranium is situated close to the solid-liquid interface; perhaps as uranium along grain boundaries, in crystal defects, or on cleavage traces of minerals that exclude uranium from their structure.

82 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Andrews, J. N.; Giles, I. S.; Kay, R. L. F.; Lee, D. J.; Osmond, J. K.; Cowart, J. B.; Fritz, P.; Barker, J. F.; Gale, J., 1982, Radioelements, radiogenic helium, and age relationships for groundwaters from the granites at Stripa, Sweden: Geochimica et Cosmochimica Acta, v. 46, no. 9, p. 1533-1543.

C) Purpose: examine the geochemistry, and isotopic relationships of U, Ra, Rd, and *He in groundwaters in the Stripa granite.

Methods: delayed neutron activation, gamma spectrometry.

Results: 2 models are developed to explain observed U-geochemistry in groundwaters of fractured crystalline rocks:

1) If uniform U distribution in matrix-preferential etch of ^{234}U is required during initial rock/water interaction to give enhanced $^{234}U/^{238}U$ for recent groundwaters.

2) If U is localized in microfractures and along grain boundaries - the above mechanism or ^{234}Th recoil generated solution of ^{234}U can lead to enhanced $^{234}U/^{238}U$ ratios. Reducing conditions may work against solution of ^{234}U.

Increases in ^{4}He are attributed to sources at depth reflecting decay of radioelements.

83. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Bacon, M. P.; Rosholt, J. N., 1982, Accumulation rates of Th-230, Pa-231, and some transition metals on the Bermuda Rise: Geochimica et Cosmochimica Acta, v. 46, no. 4, p. 651-666.

C) Purpose: determine accumulation rates of specific nuclides to evaluate the influence of abyssal sediment transport on chemical scavenging in the deep sea.

Methods: INAA, radiochemical analysis, AAS.

Results: actinide data in these cores corresponds to an average accumulation rate of 36cm/1000 years reported earlier and based on ^{14}C dating and $CaCO_3$ stratigraphy. Trace element concentrations show variations that correlate positively with $CaCO_3$cyclicity. Scavenging rates are higher than those estimated for the whole ocean.

84 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Beasley, T. M.; Carpenter, R.; Jennings, C. D., 1982, Plutonium, ^{241}Am and ^{137}Cs ratios, inventories, and vertical profiles in Washington and Oregon continental shelf sediments: Geochimica et Cosmochimica Acta, v. 46, no. 10, p. 1931-1946.

C) Purpose: determine the mobility, sources and sinks for Pu, ^{241}Am and ^{137}Cs.

Methods: mass spectrometry, low background beta counting.

Results: advection of offshore waters supplies much more Pu to shelf areas than the Columbia River or atmospheric fallout. Scavenging reactions are generally inorganic. ^{137}Cs input is predominantly from runoff (i.e. streams). Unlike Atlantic sediments, ^{137}Cs and Pu do not separate with depth in sediments. This may be related to differences in sediment porosities. Cs is apparently more downwardly mobile in Atlantic sediments.

85 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Cerling, T. E.; Spalding, B. P., 1982, Distribution and relationship of radionuclides to streambed gravels in a small watershed: Environmental Geology, v. 4, no. 2, p. 99-116.

C) Purpose: examine relationship between radionuclides and stream gravels.

Methods: wet chemical methods, gamma counting, XRD.

Results: the 3 radionuclides studied were retained by different mechanisms. ^{60}Co was held by coatings of hydrous Mn oxide on gravels. ^{90}Sr occurred primarily as an exchangeable cation, while ^{137}Cs was very tightly bound, apparently by illite in shale fragments. Fine sands and coarse silts retained the radionuclides the least. Use of this data allowed the relative contribution of individual streams to be calculated.

86. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Cerling, T. E.; Turner, R. R., 1982, Formation of freshwater Fe-Mn coatings on gravel and the behavior of ^{60}Co, ^{90}Sr, and ^{137}Cs in a small watershed: Geochimica et Cosmochimica Acta, v. 46, no. 8, p. 1333-1343.

C) Purpose: determine rate of formation and loss of Fe-Mn coating and rate of adsorption and desorption of ^{60}Co, ^{90}Sr, and ^{137}Cs.

Methods: NaI (Tl) detection, Cerenkov radiation counting, AAS.

Results: ΣFe + Mn must exceed 50 micrograms/L for Fe-Mn coatings to form; below this, coatings are lost to abrasion. Gravel with coatings of oxides (illite, quartz, and feldspar) sorbed radionuclides. Desorption results are as follows: ^{60}Co is lost by abrasion in oxidizing conditions or dissolution in reducing conditions; exchangeable ^{90}Sr is lost after 1 month while non-exchangeable ^{90}Sr takes longer to be desorbed; ^{137}Cs was totally retained.

87\. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Crabb, J.; Lewis, R. S.; Anders, E., 1982, Extinct I^{129} in C3 chondrites: Geochimica et Cosmochimica Acta, v. 46, no. 12, p. 2511-2525.

C) Purpose: ascertain if I-Xe ages of eight C3 chondrites correlate with other properties.

Methods: mass spectrometry.

Results: lack of direct correlation between I/Xe age and degree of metamorphism argues against metamorphism as a major factor in determing Ro's. Data support the conclusion that I^{129}/I^{127} was never homogenized. In some cases Ro correlates with abundances of trace I, Br, and Cd, suggesting high 129/127 in early formed meteorites and dilation of this ratio in later formed meteorites.

88 . A) Gen. Cat.--Element mobility

B) Gélinas, L.; Mellinger, M.; Trudel , P., 1982, Archean mafic metavolcanics from the Rouyn-Noranda district, Abitibi Greenstone Belt, Quebec. 1. Mobility of the major elements: Canadian Journal of Earth Sciences, v. 19, no. 12, p. 2258-2275.

C) Purpose: to present an investigation of the effects of alteration on the petrography and major element geochemistry of Archean pillowed lava flow from the Rouyn-Noranda region of the Abitibi metavolcanic belt.

Methods: petrography, chemical analyses.

Results: More than 40% of the pillows sampled retained their pristine $\sum$ FeO/MgO ratios. The various alteration patterns are independent of the initial tholeiitic or calc-alkaline lineage; this was confirmed using rare earth elements and inert trace elements such as Zr, Y, and Ti.

89 . A) Gen. Cat.--Element distribution

B) Heaman, L. M.; Shieh, Y.; McNutt, R. H.; Shaw, D. M., 1982, Isotopic and trace element study of the Loon Lake pluton, Grenville Province, Ontario: Canadian Journal of Earth Sciences, v. 19, no. 5, p. 1045-1054.

C) Purpose: to address the relationship between the monzonite core and quartz monzonite rim.

Methods: Sr and O isotopes, trace elements, petrography, Rb-Sr isotopes.

Results: the monzonite core and rim are cogenetic but the enrichment of Rb, ^{18}O, and possibly SiO_2 in the rim and the REE pattern reflects the interaction with an H_2O-CO_2 rich fluid phase derived from the country rocks.

90. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Huff, D. D.; Farrow, N. D.; Jones, J. R., 1982, Hydrologic factors and ^{90}Sr transport: a case study: Environmental Geology, v. 4, no. 1, p. 53-63.

C) Purpose: illustrate approach used in, and data from, a study of Sr-90 migration in a humid environment.

Methods: liquid scintillation counting, standard radiochemical assay.

Results: ^{90}Sr transport was consistently highest on high precipitation days. Both surface and groundwater are important in ^{90}Sr migration, but it is estimated that at least 80% is directly related to surface runoff. Groundwater may be an important agent in transporting the radionuclides to areas where it can be incorporated in surface flow.

91. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Khodakovskiy, I. L.; Malinin, A. A.; Drakin, S. I., 1982, The standard entropy of the Sr^{2+} ion in water and the enthalpy of formation of strontionite, $SrCO_3$: Geochemistry International, v. 19, no. 4, p. 102-106.

C) Purpose: recalculate standard thermodynamic values for Sr species.

Methods: calculations based on published data and isopiestic method.

Results:

	ΔH_f^o (kcal/mol)	ΔG_f^o (kcal/mol)	S^o(cal/mol°)
Sr^{2+}	-131.80 ± 0.14	-134.78 ± 0.25	-7.9 ± 0.7
$SrCO_3$	-292.95 ± 0.30	-273.57 ± 0.27	23.2 ± 0.4

The report also includes new data for Sr, SrO, $Sr(NO_3)_2$, and $Sr(NO_3)_2 \cdot 4H_2O$.

92 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) King, P. T.; Michel, J.; Moore, W. S., 1982, Groundwater geochemistry of ^{228}Ra, ^{226}Ra, and ^{222}Rn: Geochimica et Cosmochimica Acta, v. 46, no. 7, p. 1173-1182.

C) Purpose: determine controls on absolute and relative activities of Ra and Rn isotopes in groundwater.

Methods: gravimetry, gamma detection (Ge(Li)), Rn emanation.

Results: sources of ^{226}Ra, ^{228}Ra, and ^{222}Rn are temporally stable. Relationship between ^{228}Ra and ^{226}Ra does not change with lithology. Relative distribution of ^{222}Rn and ^{226}Ra may reflect cation exchange properties of the aquifers; high CEC may result in high ^{222}Rn/^{226}Ra.

93. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Kuchnir, J., 1982, The partitioning of seawater cations during the transformation of gypsum to anhydrite: Geochimica et Cosmochimica Acta, v. 46, no. 3, p. 433-446.

C) Purpose: evaluate partition coefficients of seawater cations between $CaSO_4$ and brine during transformation and elucidate the mechanism of the gypsum to anhydrite phase transformation.

Methods: lab experiments (at high temperatures to speed up reactions) where gypsum transforming to anhydrite could be observed directly, XRD, AAS.

Results: K_D's for alkalis are functions of salt content, not T. K_D's for Mg and Sr decrease with increasing T. Gypsum transformation to anhydrite occurs through dissolution and reprecipitation; at elevated T's an intermediate phase (bassanite) may be formed. K_D's for gypsum and anhydrite are too similar to use as a method of discriminating primary vs. secondary calcium sulfate minerals. However, temperature dependence of Sr and Mg may be useful in determining the temperature of transformation.

94 . A) Gen. Cat.--Element mobility

B) Long, D. T.; Angino, E. E., 1982, The mobilization of selected trace metals from shales by aqueous solutions: effects of temperature and ionic strength: Economic Geology, v. 77, no. 3, p. 646-652.

C) Purpose: to determine if brine leaching of shales can increase the metal content of subsurface solutions to levels sufficient that the solutions are potential ore-forming fluids.

Methods: XRD, chemical analyses (AA), leaching studies.

Results: results support the hypothesis that brine leaching of shales can increase metal content of sub-surface brines sufficiently that the brines could potentially serve as ore-forming fluids.Changing the salt composition of the brine changed the amount and type of mobilization. Calcium, for example, was found to be effective in leaching Pb and Zn, while K was found to be effective in mobilizing Cu.

95 . A) Gen. Cat.--Element mobility

B) Ludden, J.; Gélinas, L.; Trudel, P., 1982, Archean metavolcanics from the Rouyn-Noranda district, Abitibi Greenstone Belt, Quebec. 2. Mobility of trace elements and petrogenetic constraints: Canadian Journal of Earth Sciences, v. 19, no. 12, p. 2276-2287.

C) Purpose: to use trace element geochemistry to evaluate the validity of the geochemical subdivision of Archean volcanic rocks and to establish the controls of element mobility.

Methods: chemical analyses (XRD, INAA)

Results: qualitative evaluation of altered mafic pillows from the Rouyn-Noranda district of the Abitibi metavolcanic belt reveals that, for low-grade metamorphism, the high field strength elements (HFS: Zr, Y, Ti) and the rare earth elements (REE) are immobile. However, where alteration is extreme, the REE are leached, and redeposited by carbonate-rich and K-rich metasomatic fluids whilst Zr/Y and Zr/Ti remain unchanged. Rubidium, Ba, and to a lesser extent, Sr, are mobile at all levels of alteration. However, provided certain filters are applied, the original geochemical values of the lavas for the alkaline elements, the HFS elements, and the REE can be defined.

96 . A) Gen. Cat.--Element mobility

B) Schwarcz, H. P.; Gascoyne, M.; Ford, D. C., 1982, Uranium-series disequilibrium studies of granitic rocks. In: G. W. Bird and W. S. Fyfe (Editors), Geochemistry of Radioactive Waste Disposal. Chemical Geology, v. 36, no. 1/2, p. 87-102.

C) Purpose: to study the state of radioactive equilibrium between ^{238}U, ^{235}U, and ^{232}Th and their short lived daughters in some plutons of the Canadian Shield.

Methods: petrography, chemical analyses (delayed neutron activation)

Results: from available data, considering only whole-rock samples, there has obviously been some radioelement migration on a scale of at least a few centimeters, over the past few thousands to tens of thousands of years. However, these results are preliminary.

97 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Smith, J. N.; Ellis, K. M., 1982, Transport mechanism for Pb-210, Cs-137 and Pu fallout radionuclides through fluvial-marine systems: Geochimica et Cosmochimica Acta, v. 46, no. 6, p. 941-954.

C) Purpose: use radionuclides to determine annual cyclicity in estuarine sedimentation patterns.

Methods: Ge-Li detector, alpha spectrometry chemical methods.

Results: seasonality of radionuclide input is evident in sediment-depth profiles, and is caused by pulsed inputs of sand and clay during spring discharge, superimposed on normal sedimentation of finer silts and clays. Residence times for ^{137}Cs and ^{239,240}Pu are (for both) 1 year in the water column and 1500 year in the drainage basin. ^{210}Pb can be used to determine a precise sediment geochronology, with a time stratigraphy resolution of better than 1 year between 1963 and 1976.

98 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Tipping, E.; Cooke, D., 1982, The effects of adsorbed humic substances on the surface charge of goethite (α-FeOOH) in fresh waters: Geochimica et Cosmochimica Acta, v. 46, no. 1, p. 75-80.

C) Purpose: confirm data from previous research and clarify the effects of organics on the sorptive properties of minerals.

Methods: electrophoresis, chemical analyses, UV spectroscopy, SEM.

Results: adsorption of humic substances gives goethite a negative charge. Divalent cations (Ca^{2+}, Mg^{2+}) can decrease the magnitude of the negative charge. A plane of electrokinetic shear may be formed relatively far from the oxide surface due to the large size of the humic molecules.

99 . A) Gen. Cat.--Element mobility

B) Wadden, M. M.; Katsube, T. J., 1982, Radionuclide diffusion rates in igneous crystalline rocks. In: G. W. Bird and W. S. Fyfe (Editors), Geochemistry of Radioactive Waste Disposal: Chemical Geology, v. 36, no. 1/2, p. 191-214.

C) Purpose: to determine radionuclide diffusion rates in crystalline rocks.

Methods: diffusion studies, porosity studies, sorption studies.

Results: according to results obtained thus far, radionuclides are not expected to travel more than a few hundred meters in a period of 0.1 Ma. The results also indicate that diffusion distances in gabbros are smaller than in granites. However, retardation effects may be greater in granites than in gabbros. Some pore parameters that may play an important role in predicting retardation have been identified.

100. A) Gen. Cat.--Element mobility

B) Zielinski, R. A., 1982, The mobility of uranium and other elements during alteration of rhyolite ash to montmorillonite: a case study in the Troublesome Formation, Colorado, U.S.A.: Chemical Geology, v. 35, no. 3/4, p. 185-204.

C) Purpose: to present evidence for extensive leaching of U during alteration of rhyolite glass to montmorillonite.

Methods: chemical analyses (AA, colorimetry, delayed neutron counting technique, INAA)

Results: results indicate that major mobilization of uranium occurred. Formation of montmorillonite instead of zeolites suggests that the water was not highly saline or alkaline. In addition, radioactive equilibrium exists between ^{238}U and its decay products ^{234}U and ^{230}Th. This documents minimal open-system mobility of U within about the last 0.3 Ma.

101 . A) Gen. Cat.--Element migration

B) Balashov, V. N.; Zaraiskii, G. P.; Tikhomirova, V. I.; Postnova, L. Y., 1983, Diffusion of rock forming components in pore solutions at 200°C and 100 MPa: Geochemistry International, v. 20, no. 1, p. 28-40.

C) Purpose: determine diffusion coefficients in porous media and permeable rock.

Methods: XRD, microprobe, wet chemical methods, flame photometry, AAS.

Results: rock/solution interactions occurred in almost all cases, sometimes decreasing the diffusion coefficient "D" by 1-2 orders of magnitude. D in TiO_2 powder was generally 3 orders of magnitude greater than in granite; this is directly related to the discrepancy in porosity between the two. D in TiO_2 powder increased in the order Al, Si, Ca, Mg, Fe, Na, and K.

102. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Brookins, D. G., 1983, Migration and retention of elements at the Oklo natural reactor: Environmental Geology, v. 4, no. 3/4, p. 201-208.

C) Purpose: discuss the behavior of elements from z=34 (Se) to z=71 (Lu) at Oklo in order to draw analogies with the behavior of elements in a nuclear waste repository.

Methods: literature review.

Results: the majority of fissiogenic elements at Oklo have either not migrated or migrated only a few tens of meters (with the exception of Kr and Xe). No widespread migration of elements occurred. This indicates that rocks with more favorable geologic characteristics may be used to safely isolate radioactive waste for long periods of time.

103 . A) Gen. Cat.--Element mobility

B) Dostal, J.; Strong, D. F., 1983, Trace-element mobility during low-grade metamorphism and silicification of basaltic rocks from Saint John, New Brunswick: Canadian Journal of Earth Science, v. 20, no. 3, p. 431-435.

C) Purpose: to report data on the abundances of several trace elements in lavas of the Upper Carboniferous West Beach Formation of Saint John, New Brunswick that were metamorphosed underprehnite-pumpellyite facies conditions and to evaluate the effects of silicification upon these elements, particularly to determine whether the REE were mobilized during such a process.

Methods: chemical analyses (INAA), petrography.

Results: silicification led to simple dilution of relatively immobile elements such as rare earths, Y, Zr, Hf, Th, and Sc. The chondrite-normalized REE patterns of the silicified rocks are parallel to those of basalts.

104 . A) Gen. Cat.--Element distribution

B) Dyck, W.; McCorkell, R. H., 1983, A study of uranium-rich reduction spheroids in sandstones from Pugwash Harbour, Nova Scotia: Canadian Journal of Earth Sciences, v. 20, no. 11, p. 1738-1746.

C) Purpose: to determine the concentration and distribution of U, its decay products, and other trace elements in reduction centers in sandstones of Late Pennsylvanian-Stephanian age from Pugwash Harbour, Nova Scotia.

Methods: chemical analyses, autoradiography.

Results: the element disproportionation between host and center and the disequilibrium between parent U and daughter ^{226}Ra in the centers suggests microredox systems still active today.

105 A) Gen. Cat.--Behavior of trace elements in geomedia

B) Evans, D. W.; Alberts, J. S.; Clark, R. A., III, 1983, Reversible ion-exchange fixation of cesium-137 leading to mobilization from reservoir sediments: Geochimica et Cosmochimica Acta, v. 47, no. 6, p. 1041-1049.

C) Purpose: investigate causes for release of ^{137}Cs from sediments.

Methods: samples were taken from Par Pond at the Savannah River Plant. Analysis by flame AAS, atomic emission spectroscopy, Hydrolab Model 8000 monitor, gamma spectrometry.

Results: mobilization of ^{137}Cs during summer thermal stratification is attributed to displacement of ^{137}Cs by cations such as NH_4^+, Fe^{2+}, Mn^{2+}, from surface sites under anaerobic conditions. Atlantic and Gulf Coast sediments are clay mineral poor (relative to ORNL) and this lack of interlayer sites to accomodate cations suggests ^{137}Cs may be more mobile in these areas (interlayer sites account for 78-85% ^{137}Cs at SRP; and 99% at ORNL). By analogy, this also applies to waste repositories where anaerobic conditions and an abundance of these 3 cations could occur.

106 . A) Gen. Cat.--Element migration

B) Ferry, J. M., 1983, Mineral reactions and element migration during metamorphism of calcareous sediments from the Vassalboro Formation, south-central Maine: American Mineralogist, v. 68, no. 3 and 4, p. 334-354.

C) Purpose: to document a case of allochemical metamorphism for metamorphosed impure carbonate rocks from south-central Maine.

Methods: petrography, chemical analyses, electron microprobe.

Results: reactions indicate that H_2O was progressively lost during metamorphism, as well as K, Na, and Ca. The large fluid volumes and the observed hydrolysis reactions lead to a model that considers regional metamorphism in the area as possible large-scale acid metasomatism.

107. A) Gen. Cat.--Behavior of trace elements in geomedia or Active and semidormant hydrothermal systems.

B) Goguel, R., 1983, The rare alkalies in hydrothermal alteration at Wairakei and Broadlands, geothermal fields, N. Z.: Geochimica et Cosmochimica Acta, v. 47, no. 3, p. 429-437.

C) Purpose: study the effects of hydrothermal alteration on the concentration of the rare alkalies in natural systems at temperatures between 200 and 300°C. Methods: XRD, petrography, chemical analysis, AAS, flame emission spectrometry. Results: high K, Rb, and Cs in hydrothermal fluids must have a deeper source than the drill cores studied, since the rocks contain high concentrations of these and other alkalies. Formation of zeolites (wairakite) results in efficient scavenging of Cs from hydrothermal fluids. At temperatures above 150°C, lithium is taken up by quartz and chlorite. K and Rb are incorporated in illite and adularia.

108 . A) Gen. Cat.--Element migration or Contact metamorphism

B) Golubev, V. S., 1983, Thermodynamics of metasomatic mineral formation at mobile geochemical barriers during mass transport by infiltration: Geochemistry International, v. 20, no. 5, p. 111-117.

C) Purpose: classify geochemical barriers and examine metasomatic mineral formation.

Methods: derivations based on thermodynamic theory.

Results: 3 types of mobile geochemical barriers are distinguished: 1) Stoichiometric replacement; 2) Supersaturation; 3) Accumulation in solution. Metasomatic mineral formation is characterized by a constant rate of change in the mineral-formation region. Deposition at a type 3) barrier involves an increase in free energy, because it is linked to the reactions that form the barrier, which compensate for the increase.

109. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Mann, A. W., 1983, Hydrogeochemistry and weathering on the Yilgarn Block, Western Australia - ferrolysis and heavy metals in continental brines: Geochimica et Cosmochimica Acta, v. 47, no. 2, p. 181-190.

C) Purpose: investigate the development of acid-saline and alkaline-saline hydrogeochemical facies on the Yilgarn Block and their associated anomalous trace element concentrations.

Methods: titration, gravimetry, AAS, delayed neutron activation, anodic stripping voltammetry.

Results: acid salt lakes are located in the southwestern part of the study area in a humid (>600 mm/yr rainfall) region; neutral-alkaline lakes are located in the arid (<200 mm/yr rainfall) northeastern area. Concentrations of Na^+, K^+, Mg^{2+}, Ca^{2+}, SO_4^{2-}, and HCO_3^- are not significantly different from those in seawater. Reactions of acid water with granite bedrock have lead to anomalously high concentrations of U and Pb, and, to a lesser extent, Cu, Mn and Zn. High Fe concentrations may be responsible for low pH's, as hydrolysis of Fe (ferrolysis) results in the release of H^+ ion. Cl is probably present as ClO_2^{2+} or as a chloride; Pb exists as $PbSO_4^o$ or $PbCl_2^o$ in solution.

110. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Sholkovitz, E. R.; Cochran, J. K.; Carey, A. E., 1983, Laboratory studies of the diagenesis and mobility of $^{239,240}Pu$ and ^{137}Cs in nearshore sediments: Geochimica et Cosmochimica Acta, v. 47, no. 8, p. 1369-1379.

C) Purpose: ascertain if biogeochemical processes influence the mobility of radionuclides.

Methods: titration, colorimetry, gravimetry, AAS, of cores from Buzzards Bay.

Results: profiles developed in the cores during the experiment show development of bacterially regulated redox reactions. ^{137}Cs activity is invariant with depth and is about twice as high as in Buzzards Bay seawater, indicating that this decay product is not influenced by diagenetic reactions. Lack of a depth gradient for $^{239,240}Pu$ also indicates lack of diagenesis. Both equilibrate rapidly with sediments. Only ^{137}Cs seems to have a great vertical diffusion potential.

111 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Smith, S. P.; Kennedy, B. M., 1983, The solubility of noble gases in water and in NaCl brine: Geochimica et Cosmochimica Acta, v. 47, no. 3, p. 503-515.

C) Purpose: expand the available data on solubility of noble gases in the possible range of natural temperatures and salinities.

Methods: high-sensitivity mass spectrometry of ^{4}He, ^{22}Ne, ^{36}Ar, ^{84,86}Kr, and ^{129,130,131,132}Xe in distilled water and several laboratory prepared NaCl brines.

Results: volumetric Setschenow salting coefficients are independent of NaCl concentration up to 5.2M. Below 40°C, all T coefficients are negative. He has a minimum salting coefficient at 40°C; minima for other gases could not be determined. Order of salting coefficients: He $\lesssim$ Ne $<$ Ar $<$ Kr $<$ Xe. Dissolved salts apparently prevent formation of a solvent cage around the noble gas atom. Solubility data can be used to noble gas partitioning in 2 phase geothermal systems.

112 . A) Gen. Cat.--Elemental mobility

B) Stuart, E. J.; Bornhorst, T. J.; Rose, W. I., Jr.; Noble, D. C., 1983, Distribution and mobility of uranium and thorium in the peralkaline Soldier Meadow Tuff, Northwestern Nevada: Economic Geology, v. 78, no. 2, p. 353-358.

C) Purpose: to isolate the effects of post eruptive processes on the mobility of U and Th.

Methods: petrography, chemical analyses.

Results: initial Th/U ratio for this unit was about 2.5. Primarily crystallized specimens of the Soldier Meadow Tuff show as much as 85% U loss, average loss from oxidized rocks in which U is concentrated in and around ferromagnesian minerals. This amount could make an important source rock for U deposits.

113. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Tanaka, N.; Takeda, Y.; Tsunogai, S., 1983, Biological effect on removal of Th-234, Po-210, and Pb-210 from surface water in Funka Bay, Japan: Geochimica et Cosmochimica Acta, v. 47, no. 10, p. 1783-1790.

C) Purpose: catalog the effects of organic matter on the distribution of naturally occurring radiogenic daughters.

Methods: beta activities measured by GM counter; alpha activities measured by surface barrier silicon detector interfaced with multichannel pulse height analyzer.

Results: use of steady state model in calculating residence times of radioactive elements is not warranted. Residence time estimated with a non-steady state model is strongly dependent on biological activity. Pb-210, Th-234, Po-210 all showed minimum concentrations when biologic activity was highest.

Residence times: Th $\simeq$ Pb $\simeq$ 2Po

114. A) Gen. Cat.--Trace elements in the environment.

B) Balistrieri, L. S.; Murray, J. W.; 1984, Marine scavenging: trace metal adsorption by interfacial sediment from MANOP (Mn-nodule program) Site H: Geochimica et Cosmochimica Acta, v. 48, no. 5, p. 921-929.

C) Purpose: 1) determine trace metal adsorption properties of marine sediment and compare to metal oxides. 2) determine relative trace metal binding capacity of biogenic suspended matter, Mn-rich sediment, and clays. 3) examine binding constants on natural particles and compare to observed metal partitioning between particles and seawater.

Methods: colorimetry, AAS, γ spectroscopy.

Results: 1) Trace metal adsorption at MANOP site H is similar to adsorption by metal oxides, though the natural system takes longer to reach equilibrium.

2) Affinity sequence for interfacial sediments: Pb $>$ Fe $>$ Sn $\gtrsim$ Co $\approx$ Mn $>$ Cu

Cu $>$ Be $>$ Sc $\gtrsim$ Zn $>$ Ni $>$ Cd $\gtrsim$ Ba $>$ Cs at pH = 7.82 in natural seawater.

3) Suspended biogenic matter binds most metals more strongly than clays or Mn-sediments; Mn-sediments bind Ba, Cd, Zn, Mn, Co more strongly than clays, clays bind Cs, Be, Sn, and Fe more strongly than Mn-rich interfacial sediments.

4) Measured binding constants reflect observed metal partitioning, consistent with adsorption as the mechanism for metal retention in sedments.

114 . A) Gen. Cat.—Element mobility

B) Campbell, I. H.; Lesher, C. M.; Coad, P.; Franklin, J. M.; Gorton, M. P.; Thurston, P. C., 1984, Rare-earth element mobility in alteration pipes below massive Cu-Zn sulfide deposits: Chemical Geology, v. 45, no. 3/4, 181-202.

C) Purpose: to present the results of a study of trace element mobility in the felsic rocks associated with three Cu-Zn massive sulfide deposits from the Superior Province, Ontario.

Methods: chemical analyses (XRF, INAA)

Results: although there is no evidence of rare-earth element mobility in the pervasive low-grade alteration envelopes adjacent to the deposits, the LREE and REE plus Y have been systematically mobilized relative to the heavy REE and other trace elements in the alteration pipes beneath the ore zones.

115. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Davis, J. A., 1984, Complexation of trace metals by adsorbed organic matter: Geochimica et Cosmochimica Acta, v. 48, no. 4, p. 679-691.

C) Purpose: describe, quantitatively, metal complexation by 1) alumina surface hydroxyls, 2) organics in solution, and, 3) organic matter adsorbed on alumina surface.

Methods: adsorption experiments, specific ion electrode measurements.

Results: Cu^{2+} adsorption and solution speciation was highly controlled by organic matter; Cd^{2+} was not strongly effected by organic matter as it forms only weak complexes with organic ligands.

Particle/trace element interactions using only clean hydrous oxides may not serve as useful analogs for natural conditions, as particles in natural waters are often coated with organic matter.

116 . A) Gen. Cat.--Trace elements in geomedia

B) Jenkins, D. M.; Holloway, J. R.; Kacayonnakis, J. F., 1984, Temporal variations of aqueous constituents in a water-basalt-supercalcine system: implications for the experimental assessment of nuclear waste forms: Geochimica et Cosmochimica Acta, v. 48, no. 7, p. 1443-1454.

C) Purpose: observe alteration of supercalcine (SPC-4) at 200 and 300°C and 300 bars in water and monitor changes in aqueous constituents.

Methods: all tests were run in a Dickson-type rocking autoclave. Results were analyzed by XRD and SEM.

Results:

1) exposure of a waste form to groundwater results in rapid dissolution followed by the establishment of precipitation reactions.

2) These reactions are highly reproducible.

3) Dickson-type autoclave is a valuable tool in understanding reversible dissolution/precipitation reactions involving nuclear waste forms.

4) Only minor progress toward equilibrium was made for these solids after treatment for 2 mo. at 300°C or 3 mo. at 200°C.

117 . A) Gen. Cat.--Element mobility

B) Kizis, J. A., Jr.; Runnells, D. D., 1984, The mobility of Uranium and associated trace elements in the Bates Mountain Tuff, Central Nevada: Economic Geology, v. 79, no. 3, p. 558-564.

C) Purpose: to study the mobility of U, Th, Li, Mo, and F in the Bates Mountain Tuff.

Methods: Petrography, chemical analyses, fission-track radiography.

Results: Petrography and data on Th indicate that the Bates Mountain Tuff was originally homogeneous in composition, and appears to be a potential source rock of U.

118 . A) Gen. Cat.--Element mobility

B) Mann, A. W., 1984, Mobility of gold and silver in lateritic weathering profiles: some observations from Western Australia: Economic Geology, v. 79, no. 1, p. 38-49.

C) Purpose: to describe observations made on gold-bearing material in weathering profiles on the Tilgarn Block, Western Australia.

Methods: Petrography, electron microprobe, thermodynamic analyses.

Results: instances of both gold-silver dissolution and gold precipitation in lateritic weathering profiles have been cited in this paper. The evidence for gold precipitation in lateritic profiles has been for small crystals (<2mm) of extremely high purity.

119 . A) Gen. Cat.--Behavior of trace elements in the environment.

B) Nyffeler, U. P.; Li, Y.; Santschi, P. H., 1984, A kinetic approach to describe trace-element distribution between particles and solution in natural aquatic systems: Geochimica et Cosmochimica Acta, v. 48, no. 7, p. 1513-1522.

C) Purpose: investigate "diffusion controlled" partitioning over time.

Methods: modified suspension technique, gamma counting of adsorption and desorption experiments (adsorption on Nucleopore filters, desorption using the thin layer technique).

Results: Na, Zn, Se, Sr, Ag, Cd, Sn, Cs, Ba, Hg, Th, Pa established a constant distribution after a few days (Group I). Be, Mn, Co, Fe showed an increasing distribution over the entire time of the experiment (108 days) (Group II). Group I elements behavior is described by adsorption/ desorption reactions. Group II element behavior is described by first order lattice reaction.

120. A) Gen. Cat.--Element distribution

B) Perrault, G.; Trudel, P. ; Bédard, P.,1984, Auriferous halos associated with the gold deposits at Lamaque Mine, Quebec: Economic Geology, v. 79, no. 2, p. 227-238.

C) Purpose: to show that the Lamaque case history demonstrates that gold is a valid indicator for gold deposits.

Methods: INAA analyses of drill cuttings.

Results: authors concluded that the gold deposits originated via metamorphic fluids by successive enrichment.

121. A) Gen. Cat.--Behavior of fission products in geomedia.

B) Sholkovitz, E. R.; Mann, D. R., 1984, The pore water chemistry of ^{239,240}Pu and ^{137}Cs in sediments of Buzzard's Bay, Massachusetts: Geochimica et Cosmochimica Acta,v.45, no. 5, p. 1107-1114.

C) <u>Purpose</u>: quantify diagenesis and mobility of the artificial radionuclides ^{239,240}Pu and ^{137}Cs.

<u>Methods</u>: titration, precipitation, AAS, auto-analyzer, wet chemical oxidation, GC analysis; Pu was counted with a silicon surface barrier detector and Cs with low background beta detector.

<u>Results</u>: 1) Pronounced subsurface maximum activity of ^{239,240}Pu of .28dpm/100 kg at depths between 3 and 11 cm., followed by decrease to non-detectable levels at 20 cm. Seawater has ^{239,240}Pu activity = .01 dpm/100kg. 2) ^{137}Cs is more mobile than ^{239,240}Pu and exhibits broad maximum (3-20 cm.) of 35-40dpm/100 kg vs. 17-24 for overlying seawater. 3) Pu mobility is controlled by biological and diffusional mixing and equilibria with solid Pu phase. Pu does not undergo significant post-depositional mobility.

122. A) Gen. Cat.—Fractures <u>or</u> Radionuclides, migration

B) Smellie, J. A. T.; Rosholt, J. N., 1984, Radioactive disequilibria in mineralized fracture samples from two uranium occurrences in northern Sweden: Lithos, v. 17, no. 3, p. 215-225.

C) <u>Purpose</u>: to examine mineralized fractures from two uranium occurrences in Northern Sweden, and to establish the presence or absence of radioactive equilibrium that may indicate recent rock-water interaction processes based on the natural mobility of uranium (i.e., during the last 0.5 Ma).

<u>Methods</u>: drillcore studies, chemical analyses (radioisotope dilution, alpha spectrometry, delayed neutron activation, high resolution alpha spectrometry)

<u>Results</u>: results tend to support, at least at the depths investigated in this study, that the more harmful actinides, which are of similar chemical properties to uranium and are present in spent nuclear fuel, would also have been stable in this environment for similar periods of time.

123 . A) Gen. Cat.--Element mobility

B) Caruso, L.; Simmons, G., 1985, Uranium and microcracks in a 1,000-meter core, Redstone, New Hampshire: Contributions to Mineralogy and Petrology, v. 90, no. 1, p. 1-17.

C) Purpose: to describe the distribution of uranium in a 1,000-meter core of granite, and to demonstrate that the uranium and associated RE's have migrated extensively within the granite through microcracks.

Methods: petrography, fission tracks, electron microscope, energy dispersive x-ray analysis.

Results: an extensive set of fractures throughout a significant volume of the Mount Osceola and Conway granites were the conducts through which hydrothermal fluids containing CO_2, uranium, and RE's circulated. Microcracks facilitated fluid-rock interactions resulting in alteration and uranium redistribution.

124. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Cochran, J. K., 1985, Particle mixing rates in sediments of the eastern equatorial Pacific: Evidence from ^{210}Pb, ^{239,240}Pu, and ^{137}Cs distributions at MANOP sites: Geochimica et Cosmochimica Acta, v. 49, no. 5, p. 1195-1210.

C) Purpose: compare distribution of ^{210}Pb with that of artificial radionuclides in sediments.

Methods: gamma and alpha counting

Results: particle mixing rates calculated from excess ^{210}Pb show a variation of 3-4x at a single site. Comparison of this method with ^{137}Cs and ^{239,240}Pu sedimentation rate calculations indicates a pulse input for ^{137}Cs and Pu. ^{239,240}Pu/^{137}Cs decreases with increasing north latitude, reflecting input from Christmas Island test site. These radionuclides may be scavenged from surface waters by organic material and released into sediment during decomposition of the organics.

125. A) Gen. Cat.--Behavior of trace elements in geomedia

B) Fabryka-Martin, J; Bentley, H.; Elmore, D.; Airey, P. L., 1985, Natural iodine-129 as an environmental tracer: Geochimica et Cosmochimica Acta, v. 49, no. 2, p. 337-348.

C) Purpose: examine the potential of I-129 as an environmental tracer and dating method.

Methods: wet chemical methods, tandem accelerator mass spectrometer.

Results: subsurface production can significantly add to the iodine budget, both through leaching of I and production of ^{129}I by ^{235}U fission. ^{129}I has been used to establish circulation of 7-9million year old water in Jurassic salt domes off the Louisiana coast, and 32-40 million year old water in adjacent Miocene sediments. Results suggest that natural ^{129}I may fulfill the requirements of a hydrologic tracer.

126 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Fleischer, R. L.; Mogro-Campero, A., 1985, Association of subsurface radon changes in Alaska and the northeastern United States with earthquakes: Geochimica et Cosmochimica Acta, v. 49, no. 4, p. 1061-1071.

C) Purpose: examine use of radon in earthquake prediction.

Methods: alpha counting.

Results: most radon signals are mechanically induced. At 4 test areas, radon concentrations exhibited extrema (either maxima or minima) before earthquakes. In any area, maxima and minima were distributed among the sampling locations; this may be explained by local movements of fluids (in response to tilting) depleting radon in one location and adding it to another.

127 . A) Gen. Cat.--Behavior of trace elements in geomedia

B) Kim, K. H.; Burnett, W. C., 1985, ^{226}Ra in phosphate nodules from the Peru/Chile seafloor: Geochimica et Cosmochimica Acta, v. 49, no. 4, p. 1073-1081.

C) Purpose: evaluate uses and behavior of ^{238}U and ^{226}Ra in phosphorite nodules.

Methods: alpha and gamma spectrometry, radiochemical techniques, wet chemical analyses.

Results: young nodules contain excess ^{226}Ra, probably derived from pore fluids. Slow leakage of ^{226}Ra lowers ^{226}Ra ages relative to ^{220}Th ages. Ra flux from these sediments is 1 to 1000 times less than from deep-sea sediments or ferromanganese nodules.

FRACTURES

1. A) Gen. Cat.--Rock porosity

B) Peck, A. J., 1967, Mass transport in porous rocks: Mineralium Deposita, v. 2, no. 3, p. 243-247.

C) Purpose: to identify and briefly discuss the physical transport processes operating in the movement of substances in porous rocks.

Methods: literature review.

Results: fluid convection in permeable rocks can increase mass transfer rates by many orders of magnitude. The pressure gradient in the fluid, fluid viscosity, and the specific permeability of the rock are dominant in determining the fluid velocity and mass transfer rates.

2 . A) Gen. Cat.--Fracture permeability

B) Murray, G. H., Jr., 1968, Quantitative fracture study - Sanish Pool, McKenzie County, North Dakota: American Association of Petroleum Geologists Bulletin, v. 52, no. 1, p. 57-65.

C) Purpose: evaluate the possibility that Sanish Pool oil production is related to fractures.

Methods: well data and geologic and structure contour maps.

Results: Sanish Pool fractures serve to concentrate oil from overlying formation. Fracture porosity and permeability can be mathematically related to bed thickness and structural curvature. Best productivity coincides with greatest curvature in the Sanish Pool.

3 . A) Gen. Cat.--Media brecciation

B) Sawkins, F. J., 1969, Chemical brecciation, an unrecognized mechanism for breccia formation?: Economic Geology, v. 64, no. 6, p. 613-617.

C) Purpose: to introduce the concept of chemical brecciation and to attempt to demonstrate its application to the origin of certain breccias associated with ore deposits.

Methods: petrography, literature review.

Results: although the exact mechanism by which the rocks are broken is not understood, what appears to be a modern day example of this phenomenon has been well documented by engineers. This is known as cement aggregate reaction or alkali reactivity, and results in expansion and cracking of concrete, it is significant that aggregate material containing fine-grained silica or dolomite causes this problem, and in breccias under consideration the material between breccia fragments or the breccia fragments themselves are either fine-grained silica or dolomite.

4. A) Gen. Cat.--Fractures, intrusive-related

B) Koide, H.; Bhattecharji, S., 1975, Formation of fractures around magmatic intrusions and their role in ore localization: Economic Geology, v. 70, no. 4, p. 781-799.

C) Purpose: to show, through theoretical and computerized solutions, the types and patterns of fractures produced due to magmatic intrusions of various sizes and shapes.

Methods: mathematical analyses, stress analyses

Results: estimation of stress distribution around spheroidal and prolate magma bodies suggests development of possible zonal distribution of fractures from the periphery of the magma outward in the order of 1) continuous tension fracture zone 2) brittle fault zone 3) ductile fault zone followed by no fault zone. Brittle fault and continuous fracture zones provide excellent sites for ore mineral localization.

5. A) Gen. Cat.--fractures

B) Raybould, J. G., 1976, The influence of pre-existing planes of weakness in rocks on the localization of vein-type ore deposits: Economic Geology, v. 71, no. 3, p. 636-641.

C) Purpose: to describe some occurrences of lead-zinc mineralization and the mineralization's relationship to structure.

Methods: geologic mapping, stress analysis.

Results: any planar anisotropy in a rock could have the effects which have here been attributed principally to joints; thus bedding planes, cleavage, schistosity, igneous contacts, and shrinkage joints, as well as fold-related joints and faults, are all capable of diverting hydraulic fractures to become sites of ore deposition, especially where the angle between the potential fracture line and the pre-existing plane of weakness is low.

6 . A) Gen. Cat.--Fracture permeability

B) Nelson, R. A.; Handin, J., 1977, Experimental study of fracture permeability in porous rock: American Association of Petroleum Geologists Bulletin, v. 61, no. 2, p. 227-238.

C) Purpose: gain a better understanding of fracture permeability from experiments on the total permeability of a fractured, porous rock as a function of pressure and temperature.

Methods: intrinsic permeability was measured in a confining-pressure vessel with flow-through capabilities.

Results: fracture deformation is inelastic; matrix deforms elastically.

Fractures close or have no effect if fracture permeability approaches matrix permeability.

A permeability change is permanent if induced by pressure increase; it is elastic when induced by temperature change.

Permeability decreases with increasing T or P.

1. A) Gen. Cat.--Hydrated glasses

B) Noble, D. C., 1967, Sodium, potassium, and ferrous iron contents of some secondarily hydrated natural silicic glasses: American Mineralogist, v. 52, no. 1 and 2, p. 280-286.

C) Purpose: to discuss the sodium, potassium,and ferrous iron contents of some secondarily hydrated natural silicic glasses.

Methods: chemical analyses.

Results: in all but one sample pair the hydrated glasses have lower Na:K ratios than do the associated nonhydrated glasses. When corrected for the added water of hydration, all the hydrated glasses show an absolute decrease in Na_2O.

No leaching or gain of iron is apparent. Ferrous iron determinations on hydrated glasses from six of the eight pairs show very significant oxidation of the hydrated glasses.

2 . A) Gen. Cat.--Irradiated material

B) Berman, R. M., 1978, Differential thermal analysis of some irradiated materials: American Mineralogist, v. 63, no. 9 and 10, p. 807-813.

C) Purpose : to apply differential thermal analysis to highly radioactive irradiated materials, and measure the temperatures at which radiation damage is annealed, and the quantity of energy released.

Methods: differential thermal analysis, XRD.

Results: the annealing process is analogous to the devitrification of a glass, and the fission fragment ions act essentially like the ions of non-glass-formers when they are introduced into a glass; they provide nuclei around which ordered structures can form, and they decrease the stability of the glass. It is suggested that analogous processes occur in the annealing of metamict minerals, with alpha-decay products playing a role comparable to the fission fragments.

3. A) Gen. Cat.--Irradiated material

   B) Nassau, K.; Prescott, B. E., 1978, Growth-induced radiation-developed pleochroic anisotropy in smoky quartz: American Mineralogist, v. 63, no. 3 and 4, p. 230-238.

   C) Purpose: to re-examine the phenomenon of "anomalous pleochroism" in irradiated synthetic quartz samples.

   Methods: absorption spectrometry, emission spectrographic analyses.

   Results: it is possible to attribute the growth-induced radiation-developed pleochroic anisotropy in smoky synthetic quartz to the site-selective distribution of Al ions, possibly accompanied by charge-compensating ions, during growth on the minor rhombohedral faces.

4. A) Gen. Cat.--Irradiated material

B) Haaker, R. F.; Ewing, R. C., 1979, Differential thermal analysis of some irradiated material: discussion: American Mineralogist, v. 64, no. 9 and 10, p. 1131-1132.

C) Purpose: to review evidence that metamict materials may not be true glasses and to offer an alternative and equally plausible interpretation of the data presented by Berman (1978).

Methods: literature review.

Results: TEM studies have shown that some metamict zircons are composed of slightly misoriented zircon crystallites about .01 micrometers in diameter. In this instance, metamict zircon does not appear to be a glass. Berman's study (1978) used differential thermal analysis and XRD, and did not involve the TEM. Thus, his studies still do not preclude that the materials he studied may be non-vitreous.

5. A) Gen. Cat.--Devitrification

B) Noble, D. C.; Rose, W. I., Jr.; Zielinski, R. A., 1980, Uranium contents of glassy and devitrified andesites and dacites, Mount Mazama, Oregon: Economic Geology, v. 75, no. 1, p. 127-129.

C) Purpose: to show the variation in uranium between glassy and devitrified andesites.

Methods: petrographic, chemical.

Results: very little or no uranium was mobilized during the primary devitrification of all but two of the rocks studied. Relatively little uranium is lost during primary devitrification of many subalkaline volcanic rocks.

6 . A) Gen. Cat.--Radiation damage (alpha-recoil damage)

B) Sinclair, W.; Ringwood, A. E., 1981, Alpha-recoil damage in natural zirconolite and perovskite: Geochemical Journal, v. 15, no. 5, p. 229-243.

C) Purpose: to study the alpha-recoil damage in natural zirconolites and perovskites as an analogue to waste disposal in SYNROC.

Methods: XRD, electron microscopy, alpha dose studies.

Results: results demonstrate that zirconolite and perovskite are extremely resistant to the effects of nuclear radiation and will provide stable crystal structures for the containment of the radioactive waste elements during the time required for the radioactivity to decay to safe levels (typically 10^5-10^6 years).

7 . A) Gen. Cat.--Volcanic glass

B) Walton, A. W.; Galloway, W. E.; Henry, C. D., 1981, Release of Uranium from volcanic glass in sedimentary sequences: an analysis of two systems: Economic Geology, v. 76, no. 1, p. 69-88.

C) Purpose: to describe and compare the mechanisms and relative uranium mobilization efficiency of common diagenetic processes that alter newly deposited volcanic glass.

Methods: petrography, SEM, chemical analyses (unspecified)

Results: only total solution of glass has been shown to release uranium at a significant scale. Selective leaching of uranium without complete solution probably does not occur and evidence for slow release from alteration products is equivocal.

8. A) Gen. Cat.-- Nuclear waste disposal studies or Behavior of actinides in geomedia.

B) Pirkle, F. L.; Beckman, R. J.; Fleischhauer, H. L., Jr., 1982, A multivariate uranium favorability index using aerial radiometric data: Journal of Geology, v. 90, no. 1, p. 109-124.

C) Purpose: develop a system of evaluating aerial radiometric data.

Methods: statistical analyses.

Results: ratios of Bi-214 loading derived from a principle components (PC) analysis can be used to evaluate aerial radiometric data and locate new U deposits or favorable sites for nuclear waste disposal. This index is only appropriate if the principal components analysis is consistent with the model presented.

9\. A) Gen. Cat.—Waste glass

B) Savage, D.; Chapman, N. A., 1982, Hydrothermal behavior of simulated waste glass- and waste-rock interactions under repository conditions. In: G. W. Bird and W. S. Fyfe (Editors), Geochemistry of Radioactive Waste Disposal: Chemical Geology, v. 36, no. 1/2, p. 59-86.

C) Purpose: to describe hydrothermal experiments on two components of the near field to aid in design and modeling studies.

Methods: chemical analyses (AA, colorimetry), experimental petrology, electron microprobe.

Results: this study has revealed that the rate of release of a particular nuclide is a function of temperature and time. Cesium leach rates obtained in this manner are at least an order of magnitude lower than leach rates derived from refluxing dynamic leach tests. This is because incongruent dissolution of the glass, saturation of major components in solution and precipitation of mineral phases incorporating waste components in these closed-system experiments all serve to lower rates of radionuclide release.

10 . A) Gen. Cat.--Waste glass

B) Shade, J. W., 1982, Release kinetics and alteration of waste glass in crystalline rock systems. In: G. W. Bird and W. S. Fyfe (Editors), Geochemistry of Radioactive Waste Disposal: Chemical Geology, v. 36, no. 1/2, p. 103-121.

C) Purpose: to provide waste-form leach data from a source simulating a breached waste canister in the presence of a system dominated by crystalline rock-water interactions.

Methods: chemical analyses (plasma spectroscopy, ion chromatography)

Results: results suggest that feldspar-clay and feldspar-zeolite reactions can be used to estimate some solution parameters in the vicinity of waste packages providing rock-water equilibria dominate the system. Although the leach rates of elements from PNL-76-68 glass did not appear to be enhanced by the presence of basalt or granite, and in some cases was reduced, the effects of waste/rock mass ratios require further investigation to evaluate the role of waste form leachability on solution chemistry, and to provide necessary information for both waste package and repository design.

11. A) Gen. Cat.--Nuclear waste disposal studies

B) Smyth, J. R., 1982, Zeolite stability constraints on radioactive waste isolation in zeolite-bearing volcanic rocks: Journal of Geology, v. 90, no. 2, p. 195-202.

C) Purpose: review stability relationships of the zeolites which are common in silicic tuffs and fractures in basalts.

Methods: literature review

Results: zeolites possess cation exchange properties which are very beneficial in a repository site. However, they are unstable at high temperatures or low water vapor pressures. Zeolites break down either by reversible dehydration or irreversible mineralogical reactions. Increases in temperature cause a net volume reduction and evolution of fluids, thus providing a pathway (shrinkage fractures) and force (fluid pressure) to aid in the release of radionuclides. Upper temperature limit for zeolite stability is 95°C; only at temperatures significantly lower can zeolites aid, and not interrupt, radionuclide retention.

12. A) Gen. Cat.--Nuclear waste disposal studies

B) Crowe, B.; Self, S.; Vaniman, D.; Amos, R.; Perry, F., 1983, Aspects of potential magmatic disruption of a high-level radioactive waste repository in southern Nevada: Journal of Geology, v. 91, no. 3, p. 259-276.

C) Purpose: describe methods of evaluating the disruption of a repository by basaltic activity for consequence analyses.

Methods: hazard modelling based on published data.

Results: basaltic magmas tend to ascend rapidly (10's of cm/sec) but may be stopped temporarily and partially crystallize. Incorporation of waste in basalt magma is controlled by dimensions of dike at repository depth and depth of magma fragmentation. Waste could be dispersed with the pyroclastic component during a Strombolian eruption. Comparison to a Strombolian center indicates that 180 m^3 of waste would be incorporated into a scoria cone, 320-900 m^3 will be deposited in a scoria fall sheet (up to 12 km dispersal) and 21 m^3 will be dispersed regionally as a fine-grained aerosol.

13. A) Gen. Cat.--Leaching studies on natural and synthetic titanite

B) Hayward, P. J.; et. al., 1983, Leaching studies of natural and synthetic titanite, a potential host for wastes from the reprocessing of Canadian nuclear fuel: Canadian Mineralogist, v. 21, p. 611-623.

C) Purpose: Test for suitability of titanite as host for RAD waste disposal method and asses the stability of titanite in the anticipated environment of a vault sited 500-1000 m deep within a granitic pluton.

Methods: leaching studies were done on natural and synthetic titanite, using a synthetic groundwater composition.

Results: are favorable with calculations of solution equilibria for titanite and its main alteration products.

14. A) Gen. Cat.--Immobilization of U-Th-Ra in Waste

B) Murray, F. H.; Brown, J. R.; Fyfe, W. S.; Kronberg, B. I., 1983, Immobilization of U-Th-Ra in mine wastes by phosphate mineralizaton: Canadian Mineralogist, v. 21, p. 607-610.

C) Purpose: study behavior of U-Th-Ra

Methods: petrography, chemical analysis

Results: natural phosphates of the apatite group have high capacity for retention of U and daughter products.

HYDROTHERMAL ALTERATION AND ALTERATION STUDIES

1 . A) Gen. Cat.—Alteration studies or Behavior of clays in geomedia

B) Hay, R. L., 1960, Rate of clay formation and mineral alteration in a 4000-year-old volcanic ash soil on St. Vincent, B. W. I.: American Journal of Science, v. 258, no. 5, p. 354-368.

C) Purpose: describe soil development on a volcanic ash deposit.

Methods: particle-size analyses, petrography, field examination.

Results: the soil on the ash is generally about 6 ft. thick. Vitric lapilli have converted to halloysite·$4H_2O$. Vitric ash has converted to halloysite·$4H_2O$, allophane and hydrated ferric oxide. The soil formed at a rate of 1½-2 ft. per thousand years. Glass is almost entirely decomposed, while olivine, hypersthene and anorthite are only slightly altered. Labradorite, hornblende, and magnetite are unaltered. Survival of the generally unstable minerals may be due to soil pH or a buffering effect by the decomposing glass.

2. A) Gen. Cat.--Hydrothermal alteration

   B) Nesterenko, G. V., 1960, Certain features of skarn formation at the Tyrny-Auz deposit: Geochemistry, no. 4, p. 373-389.

   C) Purpose: discuss skarn formation and mineralization at the Tyrny-Auz deposit.

   Methods: petrography, unspecified chemical analyses.

   Results: the process of skarn formation was high-temperature contact-infiltration metasomatism with subordinate bimetasomatism. Ca, Si, Fe, Mn, and Mg were added to the country rock while alkalies, Al, and Ti were removed and redeposited.

3 . A) Gen. Cat.--Alteration studies

B) Baranov, V. I.; Lieh-T'ien, T., 1961, Relation between the concentration of uranium in zircon, monazite, and sphene of granites and the degree of alteration of these minerals: Geochemistry, no. 11, p. 1148-1150.

C) Purpose: examine relationship of U-content and alteration in minerals.

Methods: autoradiography, luminescence.

Results: degree of alteration correlates with uranium content. Altered essential minerals also show an increased density of alpha-tracks. Increased uranium contents in altered crystals may be due to addition of U during alteration.

4 . A) Gen. Cat.--Hydrothermal alteration

B) Miller, R. J. M., 1961, Wall-rock alteration at the Cedar Bay Mine, Chibougamau District, Quebec: Economic Geology, v. 56, no. 2, p. 321-330.

C) Purpose: to study and delimit alteration zones within the wall rocks at the Cedar Bay Mine.

Methods: petrography, XRD.

Results: because the host rock is essentially of one composition, an exceptional opportunity for the study of alteration is available. The differences in modes of occurrence and quantities of alteration minerals make it possible to delimit alteration zones,which are parallel to the ore shoots. The thickness of the alteration zones varies directly with the thickness of the ore shoots.

5 . A) Gen. Cat.--Alteration studies

B) Mumpton, F. A.; Roy, R., 1961, Hydrothermal stability of the zircon-thorite group: Geochimica et Cosmochimica Acta, v. 21, no. 3 and 4, p. 217-238.

C) Purpose: expand data on the solubility of zircon and thorite.

Methods: XRD

Results: hydrous zircons and thorites form by strong water adsorption in metamict crystals, not by substitution of OH^- for O^{2-} and loss of Si^{4+}. At 1550 ± 50°C, zircon dissociates to ZrO_2 and SiO_2. Data indicates that $USiO_4$ is non-existant and cannot be synthesized in the presence of water. There is little, if any, solid solution among $ThSiO_4$-"$USiO_4$"-$ZrSiO_4$.

6 . A) Gen. Cat.--Hydrothermal alteration

B) Popov, A. A., 1961, Wall rock alteration at the Uch-Ochak lead-zinc deposit: Geochemistry, no. 4, p. 334-342.

C) Purpose: describe hydrothermally altered conglomeratic sandstones.

Methods: unspecified chemical analyses.

Results: the arkosic sandstone was altered to sericite-quartz rock with pyrite and carbonate. Dark minerals are completely chloritized. Na, released by alteration of plagioclase, is not fixed in any secondary mineral and appears to have been released in solution. Experimental data indicate that solutions enriched in alkali ions intensify the decomposition of feldspars; plagioclase is less effected than K-spar.

7 . A) Gen. Cat.--Hydrothermal alteration

B) Stone, M.; Austin, W. G. C., 1961, The metasomatic origin of the potash feldspar megacrysts in the granites of southwest England: Journal of Geology, v. 69, no. 4, p. 464-472.

C) Purpose: record field data that supports a metasomatic origin for megacrysts.

Methods: field mapping, petrography.

Results: data indicate that the rock was aplitic before metasomatism. The agent of metasomatism was a liquid or vapor phase with a high K content. Metasomatism affected the entire rock and was not restricted to areas near fractures.

8. A) Gen. Cat.--Hydrothermal alteration

B) Wyllie, P. J.; Tuttle, O. F., 1961, Hydrothermal melting of shales: Geological Magazine, v. 98, no. 1, p. 56-66.

C) Purpose: to determine melting curves and products of hydrothermally melted shales in the laboratory.

Methods: melting of shales in cold-seal pressure vessels, pressure applied with water, and products analyzed by x-ray diffraction.

Results: PT curves for the beginning of melting are higher than granite melting curves. Mineralogy of partially fused shale products is given.

9 . A) Gen. Cat.--Alteration studies

B) Dickinson, W.R., 1962, Metasomatic quartz keratophyre in central Oregon: American Journal of Science, v. 260, no. 4, p. 249-266.

C) Purpose: describe the occurrence of a quartz keratophyre whose geologic relationships are clear.

Methods: petrography, XRD, wet chemical analyses.

Results: loss of NaO and enrichment of CaO occurred shortly after burial of the ash body, resulting in formation of heulandite. Local recrystallization to laumontite occurred as burial progressed. Connate waters in nearby mudstones, expelled during compaction, resulted in leaching of Ca, Mg, and K and addition of Na. Local K re-enrichment was the final phase of metasomatism of this quartz-albite rock.

10 . A) Gen. Cat.--Hydrothermal alteration

B) Ishikawa, H.; Kuroda, R.; Sudo, Toshio, 1962, Minor elements in some altered zones of "Kuroko" (black ore) deposits in Japan: Economic Geology, v. 57, no. 5, p. 785-789.

C) Purpose: to study the geochemical behavior of minor elements in the Kuroko deposits and surrounding altered zones.

Methods: chemical analyses (unspecified), thermodynamic analyses.

Results: the geochemical behavior of minor elements in the Kuroko deposits and their surrounding altered zones suggests that solute diffusion is an important mechanism controlling the distribution of elements in Kuroko and its altered zones.

11 . A) Gen. Cat.--Alteration, aqueous solutions

B) Marshall, C. E., 1962, Reactions of feldspars and micas with aqueous solutions: Economic Geology, v. 57, no. 8, p. 1219-1227.

C) Purpose: to discuss the first steps in the weathering processes of these minerals.

Methods: aqueous geochemistry studies, chemical analyses (unspecified), XRD.

Results: geometry of the aluminosilicates in question is exceedingly important. Small differences in geometry may be reflected in comparatively large differences in the bonding energies of individual cations. Hence determinations of selectivity numbers for pairs of cations and of bonding energies for individual cations provide sensitive methods for the study of dissociationg surfaces.

12 . A) Gen. Cat.--Hydrothermal alteration

B) Naboko, S. I. , 1962, Recent hydrothermal processes: Bulletin Volcanologique, v. 24, p. 142-148.

C) Purpose: to describe recent hydrothermal processes at Kamchatka and Kurile Islands.

Methods: chemical analysis of altered tocks, petrography and hydrology.

Results: hydrothermal are described and classified. Hydrothermally altered volcanic rocks are described and compositions given.

13. A) Gen. Cat.--Hydrothermal alteration

B) Wilshire, H. G.; Hobbs, B. E., 1962, Structure, sedimentary inclusions, and hydrothermal alteration of a latite intrusion: Journal of Geology, v. 70, no. 3, p. 328-341.

C) Purpose: describe and interpret structures and alteration of a latite intrusion in New South Wales.

Methods: structural analyses, petrography, XRD

Results: the latite was intruded into unconsolidated sediment which subsequently were injected into fractures in the igneous body. Alteration was caused by absorption of Na-rich water from the sediments. Diagenetic alteration of country rock far from the contact produced secondary minerals identical to the hydrothermal alteration products.

14. A) Gen. Cat.--Hydrothermal alteration

B) Zelenov, K. K., 1962, On the evacuation of dissolved aluminum and iron by thermal waters of active volcanoes on the Kurile island arc: Bulletin Volcanologique, v. 24, p. 149-153.

C) Purpose: study of Al and Fe in thermal water discharges.

Methods: chemical analysis of waters and affected rocks.

Results: alteration of volcanic rocks by hydrothermal solutions is described as are the solutions themselves.

15. A) Gen. Cat.--Hydrothermal alteration <u>or</u> Contact metamorphism

B) Green, J. C., 1963, Alkali metasomatism in a thermal gradient. Two possible examples: Journal of Geology, v. 71, no. 5, p. 653-657.

C) <u>Purpose</u>: examine conditions that lead to alkali metasomatism.

<u>Methods</u>: petrography.

<u>Results</u>: addition of K to albite has resulted in the formation of microcline at the contact of a granite pegmatite and albitite in Norway. This metasomatism is attributed to the thermal gradient that existed across the contact. Conversion of andalusite to muscovite in New Hampshire near adamellite plutons is probably due to a chemical potential, and not thermal, gradient.

16. A) Gen. Cat.--Alteration studies

B) Hawkins, D. B.; Roy, R., 1963, Distribution of trace elements between clays and zeolites formed by hydrothermal alteration of synthetic basalts: Geochimica et Cosmochimica Acta, v. 27, no. 7, p. 785-795.

C) Purpose: follow the distribution of elements during hydrothermal alteration.

Methods: spectrography, XRD.

Results: most B goes into solution; clays take up more B than zeolites. Gallium goes entirely into solid phases, about 50% in each(clay and zeolite). Most Ni enters montmorillonite. Sr does not enter clays or zeolites, but rather precipitates as a sulfate. Experimental data agrees with field observations.

17 . A) Gen. Cat.--Alteration studies or Active and semidormant hydrothermal systems

B) Hawkins, D. B.; Roy, R., 1963, Experimental hydrothermal studies on rock alteration and clay mineral formation: Geochimica et Cosmochimica Acta, v. 27, no. 10, p. 1047-1054.

C) Purpose: assess the physico-chemical factors that determine the assemblage of clay minerals developed during hydrothermal alteration.

Methods: XRD, wet chemical techniques.

Results: silica content has a great effect on rate of alteration; rate varies inversely with amount of silica. Carbonic acid solutions yield mainly illite with minor montmorillonite and analcite. Structure of the parent material affected only rate of alteration, not mineralogy of alteration phases.

18. A) Gen. Cat.--Hydrothermal alteration <u>or</u> Behavior of actinides in geomedia

B) Leonora, L. L., 1963, Uranium and thorium in hydrothermally altered rocks of the Kzyl-Ompul Mountains (northern Tien-Shan): Geochemistry, no. 6, p. 566-571.

C) <u>Purpose</u>: investigate behavior of U and Th in hydrothermally altered rocks.

<u>Methods</u>: luminescence, wet chemical techniques

<u>Results</u>: hydrothermal alteration of the Kzyl-Ompul massif occurred in 2 stages and involved the introduction of Th and U and little else. Th was introduced early on as alkalic syenites were intruded; U was brought in during the later intrusion of leucocratic granites.

19. A) Gen. Cat.--Hydrothermal alteration

B) Harvey, R. D.; Vitaliano, C. J., 1964, Wall-rock alteration in the Goldfield District, Nevada: Journal of Geology, v. 72, no. 5, p. 564-579.

C) Purpose: interpret conditions of wall-rock alteration.

Methods: XRD, petrography.

Results: hydrothermal alteration of dacite, latite, and andesite has produced the following zones: 1) propylitic zone farthest from gold veins; 2) argillic zone (montmorillonite, illite, and kaolinite); 3) alunite quartz zone adjacent to gold veins. Alunite is formed by this reaction:

$$KAl_3Si_{10}(OH)_{2(s)} + 4H^+_{(aq)} + 2SO_4^{2-}{}_{(aq)} \text{-----}\rightarrow KAL_3(SO_4)_2(OH)_{6(s)} + 3SiO_{2(s)}$$

20. A) Gen. Cat.--hydrothermal alteration

B) Hemley, J. J.; Jones, W. R., 1964, Chemical aspects of hydrothermal alteration with emphasis on hydrogen metasomatism: Economic Geology, v. 59, no. 4, p. 538-569.

C) Purpose: to discuss the importance of hydrogen metasomatism in hydrothermal alteration.

Methods: thermodynamic analyses, chemical data from literature

Results: it is concluded that the most significant controls on solution composition are: 1) nature of the wall rock; 2) changes in the pressure-temperature state of the aqueous phase such as occur with throttling and boiling, with possible fractionation of volatile components; 3) mixing of hypogene solutions with supergene solutions or ground water; and 4) oxidation of H_2S to stronger sulfur acids.

21 . A) Gen. Cat.--Hydrothermal alteration

B) Iwasaki, I., 1964, Alteration of rock by volcanic gas in Japan: Bulletin Volcanologique, v. 27, p. 65-78.

C) Purpose: to clarify the process of alteration of rocks by hydrothermal systems.

Methods: by comparing variations in chemical composition of the series of alteration products from several localities issuing volcanic gasses in Japan, and by model experiments, for example placing small pieces of rock and minerals in active fumaroles and also hot springs and various solutions containing various salts, acids and concentrations.

Results: changes in composition of altered rocks are noted and discussed.

22. A) Gen. Cat.--Hydrothermal alteration

B) Němec, D., 1964, Minor elements as indicators of the origin of West Moravian skarns: Geochemistry International, v. 1, no. 2, p. 205-212.

C) Purpose: use trace element data to ascertain the origin of West Moravian skarns.

Methods: spectrography, petrography.

Results: the skarns contain higher contents of Pb, Zn, Sn, Ge, and B then the surrounding amphibolites, plus trace Ag, Bi, and In. Nearby lime-silicate skarns do not contain indium. Data indicate that the West Moravian skarns could not be derived from sedimentary Fe deposits as previously hypothesized.

23 . A) Gen. Cat.--Alteration studies

B) Ostroff, A. G., 1964, Conversion of gypsum to anhydrite in aqueous salt solutions: Geochimica et Cosmochimica Acta, v. 28, no. 9,p. 1363-1372.

C) Purpose: obtain solubility data for $CaSO_4$ in Na-Mg solutions.

Methods: XRD, wet chemical methods.

Results: gypsum converts to anhydrite in salt solutions at 90.5°C, through an intermediate hemihydrate phase. Thermodynamic calculations support observed results. Gypsum converts to anhydrite in pure $CaSO_4$ solutions at $\geq$ 97°C.

24. A) Gen. Cat.--Hydrothermal alteration

B) Sigvaldason, G. E., 1964, Some geochemical and hydrothermal aspects of the 1961 Askja eruption: Contributions to Mineralogy and Petrology, v. 10, p. 263-274.

C) Purpose: to monitor changes in hydrothermal activity before the eruption of Askja.

Methods: chemical analysis of waters and also pumice to compare with water compositions.

Results: chemical characteristics of thermal waters are given for a number of instances during the sequence before the eruption of Askja. Comparison with leachates of pumice and the waters and various incrustations and sublimates are discussed.

25 . A) Gen. Cat.--Hydrothermal alteration

B) Zlobin, B. I.; Pevtsova, L. A., 1964, Behavior of lead and zinc in some processes of hydrothermal alteration of granitoids: Geochemistry International, v. 1, no. 3, p. 413-420.

C) Purpose: evaluate hydrothermal alteration of granites as a source for ore metals.

Methods: dithizone method.

Results: propylitization does not remove either Pb or Zn; carbonitization does not cause removal until quartz is attacked, and then Pb is removed more quickly than Zn. During epidolitization, Zn is more mobile than Pb. Field relations indicate that neither of these processes could account for lead-zinc ore bodies in this area.

26 . A) Gen. Cat.--Hydrothermal alteration

B) Bonatti, E., 1965, Palagonite, hyaloclastites and alteration of volcanic glass in the ocean: Bulletin Volcanologique, v. 28, no. 3,p. 257-270.

C) Purpose: to understand palagonization and alteration of sub-aqueous basaltic volcanics.

Methods: review of previous work plus chemical analysis.

Results: palagonization is thought to take place at relatively high temperatures. Palagonite devitrifies faster than unhydrated glass. This is discussed.

27 . A) Gen. Cat.--Alteration, potassic

B) Meyer, C., 1965, An early potassic type of wall-rock alteration at Butte, Montana: American Mineralogist, v. 50, no. 10, p. 1717-1722.

C) Purpose: to describe potassic alteration adjacent to molybdenite-bearing quartz veinlets at Butte, Montana.

Methods : petrography

Results: within the envelopes of alteration the feldspars and micas are altered to a fine-grained assemblage of muscovite, biotite, alkali-feldspar (Or_{70}), and quartz, together with anhydrite, carbonate, magnetite, hematite, pyrite, and chalcopyrite. The quartz-molybdenite veinlet itself may also contain small amounts of any of the foregoing minerals except biotite. At their outer edges the alteration envelopes grade into fresh quartz monzonite. There is no marginal argillic zone.

28 . A) Gen. Cat.--Hydrothermal alteration

B) Moxham, R. M.; Foote, R. S.; Bunker, C. M., 1965, Gamma-ray spectrometer studies of hydrothermally altered rocks: Economic Geology, v. 60, no. 4, p. 653-671.

C) Purpose: to study areas of potassic alteration with a gamma-ray spectrometer, in order to determine what other radioelements might be involved in the hydrothermal alteration.

Methods: chemical analyses (unspecified), gamma-ray spectrometry.

Results: in the areas studied, potassium in the more intensely altered zones is about twice that in unaltered areas. There is no corresponding increase in thorium, so a higher potassium/thorium ratio also results from alteration; abnormally high uranium, locally in secular disequilibrium, was observed at the Bagdad porphyry copper deposit.

29. A) Gen. Cat.--Hydrothermal alteration, geothermal systems (active)

B) Schoen, R.; White, D. E., 1965, Hydrothermal alteration in GS-3 and GS-4 drill holes, Main Terrace, Steamboat Springs, Nevada: Economic Geology, v. 60, no. 7, p. 1411-1421.

C) Purpose: to describe the alteration mineralogy in the core from two drill holes in the Main Terrace, the most active part of the area, and to consider briefly the relationships between the alteration and the present spring waters.

Methods: petrography, XRD, chemical analyses (unspecified).

Results: the K^+/H^+ ratio in the deep high-temperature waters suggests that the waters are in equilibrium with K-mica. Therefore, the present-day spring waters may still be producing the observed hydrothermal alteration. This hypothesis, coupled with the proven ability of these waters to deposit metals, indicate that the spring waters are similar to some ore-forming fluids.

30 . A) Gen. Cat.--Hydrothermal alteration

B) Thurber, D., 1965, The concentration of some natural radioelements in the waters of the Great Basin: Bulletin Volcanologique, v. 28, no. 2, p. 195-204.

C) Purpose: to understand radioelements geochemical behavior during weathering and gain information on radionuclides in natural waters.

Methods: U^{238}, U^{234}, Th^{230}, Ra^{226}, and Th^{232} and Th^{228} were separated from collected samples of stream waters, underground waters and a hot spring and analyzed by various chemical means. Results of the various samples analyzed are compared.

Results: the hot spring was analyzed thoroughly and may be a good example of least fractionation of nuclides. Analysis of other samples is discussed.

31 . A) Gen. Cat.--Hydrothermal alteration

B) Ellis, A. J., 1966, Volcanic hydrothermal areas and the interpretation of thermal water compositions: Bulletin Volcanologique, v. 29, p. 575-584.

C) Purpose: to interpret thermal water compositions from New Zealand.

Methods: chemical analysis of waters in the light of experimental work done on volcanic rock reactions with water under high temperatures and pressures.

Results: composition of the water is discussed in relation to experimental data and mechanisms for the hydrothermal dynamics are discussed.

32 . A) Gen. Cat.--Hydrothermal alteration

B) Němec, D., 1966, Plagiclase albitization in the lamprophyric and lamproid dykes at the eastern border of the Bohemian Mass: Contributions to Mineralogy and Petrology, v. 12, p. 340-353.

C) <u>Purpose</u>: to determine amount of albitization and its relationship to whole rock.

<u>Methods</u>: petrography.

<u>Results</u>: basic plagioclase has been albitized widely in the dykes. Various lines of evidence are followed, relation between albitization and alteration of mafic minerals is discussed.

33 . A) Gen. Cat.--Hydrothermal alteration

B) Oleynikov, B. V., 1966, Infiltrational metasomatism around the middle reaches of the River Gorbiachin: Geochemistry International, v. 3, no. 6, p. 1207-1217.

C) Purpose: gain a better understanding of metasomatic processes.

Methods: petrography, "chemical analyses."

Results: metasomatism was caused by the injection of small portions of an acid hybrid magma. Arenaceous limestones were converted to diopside-wallastonite metasomatites. Scapolitization later affected both the intrusives and the country rock. K, Mg, Fe, Na, Al, and Ca were all added to the wall rock during metasomatism.

34 . A) Gen. Cat.--Hydrothermal alteration

B) Pampura, V. D., 1966, Behavior of rubidium, lithium, barium, and strontium in wall rock metamorphism of granitoids (taking as examples the molybdenum deposits of the eastern Transbaikal region): Geochemistry International, v. 3, no. 6, p. 1244-1256.

C) Purpose: consider the effect of chemical reactions and crystallographic factors in the wallrock alteration of granitoids.

Methods: flame photometry.

Results: this type of alteration is characterized by extensive migration of elements. Potash feldspathization leads to the accumulation of Rb, Sr, and Ba; argillization is accompanied by the same enrichment but to a lesser extent. Li does not form highly concentrated zones, but is enriched in zones of quartz-kaolinite replacement, where there is also a maximum loss of Rb. pH of solutions as well as crystallochemical properties of the minerals and ions control their distribution. An empirical series of geochemical availability is as follows: Li(Na) > Ba,Sr > Rb(K).

35 . A) Gen. Cat.--Hydrothermal alteration

B) Rogers, J., 1966, Hydrothermal melting of some New Zealand greywackes and argillites: Bulletin Volcanologique, v. 29, p. 173-176.

C) Purpose: to understand melting of greywackes and argillites under high water pressure.

Methods: powdered samples were placed in cold seal bombs and heated while water pressure was controlled for up to twelve days. Then the bombs were quickly cooled. Samples were analyzed by x-ray diffraction and petrographic microscope.

Results: a PT curve was developed and is discussed.

36 . A) Gen. Cat.--Hydrothermal alteration

B) Facca, G.; Tonani, F., 1967, The self-sealing geothermal field: Bulletin Volcanologique, v. 30, p. 271-273.

C) Purpose: to examine the process of an hydrothermal system without a caprock producing an impermeable caprock.

Methods: petrography, hydrology, and chemical analysis of waters.

Results: processes for the development of a cap rock above a hydrothermal permeable aquifer are described and discussed.

37 . A) Gen. Cat.--Hydrothermal alteration

B) Fournier, R. O., 1967, The porphyry copper deposit exposed in the Liberty open-pit mine near Ely, Nevada. Part II. The formation of hydrothermal alteration zones: Economic Geology, v. 62, no. 2, p. 207-227.

C) Purpose: to describe the formation of hydrothermal alteration zones in the Liberty pit.

Methods: petrography, chemical analyses (unspecified)

Results: in the southwest part of the Liberty pit a large porphyry body exhibits a zonal alteration pattern related to fissures and pyrite-bearing veins. The outermost zone contains unaltered K-feldspar, kaolinite after plagioclase, and black biotite after hornblende. An intermediate zone contains reconstituted K-feldspar, phlogopitic biotite, and muscovite or muscovite plus K-feldspar replacing only plagioclase. In the innermost zone, the only silicates are quartz and muscovite. In some places an alteration band of K-feldspar after plagioclase separated kaolinite and muscovite. The zonally distributed alteration at Ely is considered to have taken place after the rock had cooled to below 250°C.

38. A) Gen. Cat.--Hydrothermal alteration

B) Fullagar, P. D.; Brown, H. S.; Hagner, A. F., 1967, Geochemistry of wall rock alteration and the role of sulfurization in the formation of the Ore Knob sulfide deposit: Economic Geology, v. 62, no. 6, p. 798-825.

C) Purpose: to study the wall rock of the deposit with the hope of determining the source of the metals and the origin of the ore.

Methods: geologic mapping, petrography, chemical analyses (titrimetry, XRF, colorimetry)

Results: chemical analyses of the wall rock gneiss at Ore Knob reveal that iron decreases toward the ore body. The distributions of copper and sulfur in the wall rock gneiss support the idea of introduction of these elements from a distant source, whereas the distribution of iron does not support this idea. Calculations indicate that enough iron was removed from the wall rock gneiss to account for all the iron in the ore body.

39. A) Gen. Cat.--Hydrothermal alteration

B) Gavrilin, R. D.; Pevtsova, L. A.; Klassova, N. S., 1967, Behavior of lead and zinc in the hydrothermal alteration of intrusive rocks: Geochemistry International, v. 4, no. 4, p. 790-799.

C) Purpose: determine possible sources of ores.

Methods: petrography, other methods not discussed.

Results: intense propylitization can liberate large quantities of both Pb and Zn, but probably only occurs on a small scale. Low-temperature albitization and sericitization can also result in intense leaching of Pb and Zn, and can occur on a large enough scale to bring considerable amounts of these elements into solution.

40 . A) Gen. Cat.--Hydrothermal alteration

B) Gresens, R. L., 1967, Tectonic-hydrothermal pegmatites I. The model: Contributions to Mineralogy and Petrology, v. 15, p. 345-355.

C) Purpose: to propose a model for the genesis of complex zoned pegmatites.

Methods: use of previous experimental studies to form a model for the genesis of complex zoned pegmatites by calling on the interplay of mechanical and chemical forces.

Results: two basic conditions are called on:1)an alkali chloride intergranular fluid phase is in equilibrium with the solid phases in the host rock. 2) deformation produces low pressure zones in the host rock. Based on these two conditions, various mechanisms are called on and are discussed for the pegmatite genesis.

41 . A) Gen. Cat.--Hydrothermal alteration

B) Gresens, R. L., 1967, Tectonic-hydrothermal pegmatites II. An example: Contributions to Mineralogy and Petrology, v. 16, p. 1-28.

C) Purpose: to illustrate a model for formation of pegmatites by hydrothermal processes with an example.

Methods: major and trace element analysis, general and structural geology analysis.

Results: it is demonstrated that the Kiawa pegmatites, New Mexico, formed according to the model outlined in part one of this study. (Gresens: Tectonic-hydrothermal pegmatites I. The model: Contributions to Mineralogy and Petrology, v. 15, p. 345-355).

42 . A) Gen. Cat.--Hydrothermal alteration

B) Rao, M. N., 1967, Abundance pattern of the rare earth elements in uranium minerals: Earth and Planetary Science Letters, v. 2, p. 394-396.

C) Purpose: to understand REE patterns (regularities of distribution) in uraninites and pitchblendes.

Methods: analysis of REE in various uraninites and pitchblends is taken from various workers. The abundances of REE in uranium minerals are normalized to chondritic REE abundances.

Results: pure pitchblendes show 1% total REE content while uraninites show 1-10% total REE. Europium is considerably depleted in uraninite but shows normal abundance in pitchblendes. Pitchblendes are regarded as having originated from hydrothermal solutions, derived from rest magmatic solutions, or as alteration products of uraninite. Hydrothermal solutions may oxidize Eu to 3+ state and thus mobilize it to join the other REE's in pitchblende. In pegmatitic solutions, Eu may be reduced, not allowing it to fit the uraninite structure because of its atomic radius. Oxidation and reduction mechanisms are not known here.

43 . A) Gen. Cat.--Hydrothermal alteration

B) Gellatly, D. C.; Hornung, G., 1968, Metasomatic nepheline-bearing gneisses from Darkainle, Somali Republic: Journal of Geology, v. 76, no. 6, p. 678-691.

C) Purpose: describe the nepheline bearing gneisses and discuss the process responsible for their origin.

Methods: petrography, XRF.

Results: metasomatic nepheline gneisses are richer in biotite and Ca-plagioclase than nepheline syenites and have more CaO, MgO, and TiO_2 and less Na_2O and Al_2O_3. The nephelinitization process involves addition of Na_2O, Al_2O_3 and SiO_2 and loss of basic oxides. The solutions responsible for metasomatism were probably derived through hydrothermal alteration of magmatic nepheline syenites, but may have been a residuum of a syenitic magma.

44. A) Gen. Cat.--Hydrothermal alteration

B) Gjelsvik, T., 1968, Distribution of major elements in the wall rocks and the silicate fraction of the Skorovass pyrite deposit, Grong area, Norway: Economic Geology, v. 63, no. 3, p. 217-231.

C) Purpose: to discuss the distribution of Si, Al, Fe, Mg, Ca, Na, and K in the wall rocks and the interlayered beds.

Methods: petrography, chemical analyses (flame photometry, standard silicate analysis, gravimetric determinations, spectrometry)

Results: the ore formation at Skorovass was attended by pronounced chemical alterations of the wall rocks and the gangue mineral fraction, such as strong leaching of Na and Ca, some leaching of Si, whereas Mg was added, perhaps also K. Of other elements investigated, Fe and Al showed only slight changes.

45 . A) Gen. Cat.--Hydrothermal alteration

B) Graeser, S., 1968, Lead isotopes and minor elements in galenas and sulfosalts from Binnatal: Earth and Planetary Science. Letters, v. 4, p. 384-392.

C) Purpose: to yield more evidence on the genesis of the unusual minerals at Binnatal and to prove the theory that the unusual mineralizations were caused by mixing of As, Sb, etc. into an existing galena, sphalerite, pyrite association by hydrothermal solutions during orogeny.

Methods: lead and sulfur isotopes were measured in a number of the mineral samples, as well as from areas suspected of contributing As and Sb to the hydrothermal solutions and compared. Minor elements analysis was also done on all the samples.

Results: galenas were put into a number of groups based on differing lead ratios. Trace elements and $\delta^{34}S$ were found to show significant similarities to the lead. Bi, for instance, shows a positive concentration rise with Pb^{206}/Pb^{204} rise. Sb shows the opposite trend. Finally, mixing of B-Type and J-Type leads, can explain most of the isotope compositions of the minerals.

46 . A) Gen. Cat.--Hydrothermal alteration

B) Hall, W. E.; Heyl, A. V., 1968, Distribution of minor elements in ore and host rock, Illinois-Kentucky fluorite district and Upper Mississippi Valley zinc-lead district: Economic Geology, v. 63, no. 6, p. 655-670.

C) Purpose: to present data on the distribution of minor elements in ore and gangue minerals and in adjacent host rock from the Illinois-Kentucky fluorite district and the Upper Mississippi Valley zinc-lead district.

Methods: chemical analyses (spectrographic analyses); XRD.

Results: the ore of the Illinois-Kentucky fluorite district is characterized by greater abundance of minor elements than in other Mississippi Valley deposits, by large fractionation of silver between galena and sphalerite, and by a low ratio of antimony to silver in galena. Silver and antimony are concentrated in the galena and show a marked zonal pattern within the district. Sphalerite is high in cadmium, gallium, and germanium. It is concluded that the minor elements were largely leached from the basement by convective circulation of heated oilfield brine.

47 . A) Gen. Cat.--Hydrothermal alteration

B) Keller, W. D.; Hanson, R. F., 1968, Hydrothermal alteration of a rhyolite flow breccia near San Luis Potosi, Mexico, to refractory kaolin: Clays and Clay Minerals, v. 16, no. 3, p. 223-229.

C) Purpose: describe the genesis of a hydrothermal kaolinite deposit.

Methods: petrography, XRD, DTA, wet chemical analyses.

Results: data indicate the following steps in formation of the deposit: 1) mobilization of Fe, concentration of Fe in unaltered areas; 2) mobilization and removal of alkalis, alkaline earths; silica mobilization and redeposition; 3) further desilication yielding pure but poorly ordered kaolinite. The presence of alunite indicates the most probable loci of rising solutions.

48 . A) Gen. Cat.--Hydrothermal alteration

B) Levinson, A. A.; Day, J. J., 1968, Low temperature hydrothermal synthesis of montmorillonite, ammonium-micas and ammonium-zeolites: Earth and Planetary Science Letters, v. 5, p. 52-54.

C) Purpose : to synthesize montmorillonite-group minerals from kaolinite, quartz, and carbonates and the addition of (with respect to previous studies) illite and feldspar at low temperature (300°C).

Methods: mixing of various natural minerals and ammonium-hydrothermal systems.

Results: several naturally occurring mineral combinations such as 1) dolomite + kaolinite + quartz; 2) dolomite + illite + quartz; 3) dolomite + feldspar + quartz; and 4) dolomite + feldspars. Addition of ammonia or ammonium hydroxide produces ammonium phases such as NH_4-mica and NH_4-analcime. It is suggested that these reactions may take place under favorable diagenetic and hydrothermal conditions.

49 . A) Gen. Cat.--Hydrothermal alteration

B) Nilsson, C. A., 1968, Wall rock alteration at the Boliden deposit, Sweden: Economic Geology, v. 63, no. 5, p. 472-494.

C) Purpose: to investigate the mineralogical and chemical changes of the wall rocks of the Boliden sulfide ore body.

Methods: petrography, chemical analyses (unspecified), XRD.

Results: compared to the unaltered rocks the central zone shows addition of Al_2O_3, K_2O, TiO_2, SiO_2, and H_2O. The proportions of these components are shown to change with vertical distance from the sulfide ore. The outer zone shows a definite addition of MgO, total Fe, H_2O, and S. Throughout the alteration envelope there is a remarkable loss of CaO and Na_2O. The central zone has lost total Fe and MgO. Compared to the calculated original composition of the rock complex, the whole altered body (not counting the sulfide ore) has suffered a loss of Na_2O, CaO, and total Fe and gained Al_2O_3, TiO_2, MgO, K_2O, H_2O, S, and F.

50. A) Gen. Cat.--Hydrothermal alteration

B) Pampura, V. D.; Trufanova, L. G., 1968, Lithium and cesium in zones of argillic alteration, Baleysk gold deposit (Eastern Transbaikal): Geochemistry International, v. 5, no. 4, p. 825-827.

C) Purpose: examine effects of an epithermal gold deposit on the chemistry of surrounding rocks.

Methods: none discussed.

Results: the altered zones are highly enriched in Li (~400 ppm) and Cs (45 ppm, average). Highest Li concentrations are in the inner zone of the alteration halo in the zone of kaolinitization and quartz-kaolinite replacement; kaolinite is the principal carrier (700 ppm or more Li). 88-90% of this Li is bound within the crystal structure of kaolinite. Cs is generally bound in hydromicas, and the highest concentrations (up to 83 ppm) are found in the quartz-kaolinite-hydromuscovite zone.

51. A) Gen. Cat.--Hydrothermal Alteration

B) Senderov, E. E., 1968, Experimental study of crystallization of sodium zeolites under natural conditions: Geochemistry International, v. 5, no. 1, p. 1-12.

C) Purpose: determine conditions of formation of Na zeolites in nature.

Methods: petrography, XRD.

Results: slow synthesis of analcime and natrolite occurs at lower temperatures than fast crystallization, and permits the growth of albite. Formation of garronite, chabazite, mordenite, and silica-rich analcime is ascribed to metastable growth from highly reactive initial material. Data support evidence concerning the upper stability temperature (240°C) for analcime under conditions of the "zeolite" facies.

80 . A) Gen. Cat.--Hydrothermal alteration

B) Miroschnichenko, L. A.; Kalinin, S. K.; Zamyatina, G. M., 1971, Germanium in the skarns of central Kazakhstan: Geochemistry International, v. 8, no. 3, p. 371-374.

C) Purpose: obtain data on conditions of concentration of Ge and its value as a geochemical indicator.

Methods: quantitative spectrography.

Results: Ge accumulates in post-magmatic solutions during crystallization of felsic magmas. Highest Ge concentrations are found in skarns of granite contacts; skarns of intermediate intrusives are much poorer in Ge. During crystallization of mafic magmas, Ge follows Fe into ferromagnesian minerals, and virtually none is left over for postmagmatic alteration.

81 . A) Gen. Cat.--Hydrothermal alteration

B) Nash, J. T.; Theodore, T. G., 1971, Ore fluids in the porphyry copper deposit at Copper Canyon, Nevada: Economic Geology, v. 66, no. 3, p. 385-389.

C) Purpose: to describe a previously undocumented fluid environment established near the intrusive contact of a shallow Tertiary intrusion with siliceous Paleozoic sediments.

Methods: petrography, fluid inclusions.

Results: fluid chemistry studies indicate that in the contact zone there were dense, highly saline fluids, while later and peripheral to the stock fluids were appreciably less dense. Apparently, metal zonation in the district is related to the fluid zonation.

82 . A) Gen. Cat.--Alteration studies

B) Reed, J. C., Jr.; Morgan, B. A., 1971, Chemical alteration and spilitization of the Catoctin greenstones, Shenandoah National Park, Virginia: Journal of Geology, v. 79, no. 5, p. 526-548.

C) <u>Purpose</u>: examine compositional changes in Catoctin Formation.

<u>Methods</u>: petrography, microprobe.

<u>Results</u>: the principal changes during spilitization of the lavas were enrichment in Na, Mg, and H, and depletion of O and Ca. Chemical alteration was due to the circulation of oxidizing fluids through a fissure system either shortly after eruption or during Paleozoic regional metamorphism.

83 . A) Gen. Cat.--Alteration studies

B) Scott, R. B., 1971, Alkali exchange during devitrification and hydration of glasses in ignimbrite cooling units: Jounal of Geology, v. 79, no. 1, p. 100-110.

C) Purpose: identify degree and mechanisms of alteration (particularly alkali exchange with groundwaters) of ignimbrite units.

Methods: colorimetry, AAS.

Results: the alkali exchange process is most active during the cooling period of the ignimbrite; thick ignimbrites display the greatest degree of alkali exchange. Groundwater removes alkalies from partially or non-welded margins of coolingunits. Loss of alkalies is correlated with devitrification and secondary hydration.

84 . A) Gen. Cat.--Hydrothermal alteration

B) Shraga, M. G., 1971, The hydrothermal iron deposits of the Menuha Ridge: Israel Journal of Earth Science, v. 20, no. 2, p. 51-88.

C) Purpose: to examine the mineralization, mode of formation, and economic potential of the Menuha iron deposits.

Methods: petrography, geologic mapping, chemical analyses (unspecified)

Results: mineralization is accompanied by metasomatic changes in limestone country rock, mainly in the form of dolomitization and silicification. The phenomena are apparently caused by hydrothermal solutions within the 100-250°C range, pH values of 6 to 8, and Eh values between .23 and -0.05. The mineralization is Tertiary and probably related to intrusive activity.

85. A) Gen. Cat.--Alteration studies

B) van Moort, J. C., 1971, A comparative study of the diagenetic alteration of clay minerals in Mesozoic shales from Papua, New Guinea, and in Tertiary shales from Louisiana, USA: Clays and Clay Minerals, v. 19, no. 1, p. 1-20.

C) Purpose: describe diagenetic effects on shales of different ages.

Methods: XRD, XRF, AAS, flame photometry.

Results: diagenetic reactions (conversion of montmorillonite to illite) are similar in both the Mesozoic and Tertiary shales. Depth of burial, rather than stratigraphic position, controls the proportion of expandable material present. Differences in MgO and K_2O content, and mineralogy, demonstrate a higher proportion of relatively unweathered material in the Tertiary samples.

86. A) Gen. Cat.--Alteration studies

B) Wardlaw, N. C.; Reinson, G. E., 1971, Carbonate and evaporite deposition and diagenesis, Middle Devonian Winnipegosis and Prairie Evaporite Formations of southcentral Saskatchewan: American Association of Petroleum Geologists Bulletin, v. 55, no. 10, p. 1795-1786.

C) Purpose: establish relations between carbonate banks and associated carbonate and evaporite sediments.

Methods: analysis of well logs and cores, petrography.

Results: generally, these rocks were deposited under uniform and extremely quiet water conditions. Anhydrites were grown displacively in a submarine (not supratidal) environment, and were later dolomitized. Interfingering of anhydrite and halite suggests that these are facies equivalents.

87 . A) Gen. Cat.--Hydrothermal alteration

B) Flörhe, O. W.; Langer, K., 1972, Hydrothermal recrystallization and transformation of tridymite: Contributions to Mineralogy and Petrology, v. 36, p. 221-230.

C) Purpose: to determine products of hydrothermal recrystallization of tridymite.

Methods: tridymites containing .016% Na - .004% Na were prepared. They were hydrothermally treated at temperatures between 815-950°C and 200 bars H_2O. Optical and x-ray diffraction analysis of products was made.

Results: recrystallization of tridymite or transformation into quartz depends mostly on Na content. Na $<$ .015%, then the tridymite is within the quartz field. Na $>$ .03%, then quartz is in the tridymite field. Mechanisms are discussed.

88. A) Gen. Cat.--Hydrothermal alteration

B) Ineson, R. R.; Mitchell, J. G., 1972, Isotopic age determinations on clay minerals from lavas and tuffs on the Derbyshire orefield: Geological Magazine, v. 109, p. 501-512.

C) Purpose: to determine if clay minerals and igneous rocks from Derbyshire have been hydrothermally altered and when they were.

Methods: x-ray diffraction, K-Ar dating.

Results: igneous rocks were hydrothermally altered, clay minerals were also altered hydrothermally during several episodes. Relation between the igneous rocks and alteration products is discussed briefly.

89. A) Gen. Cat.--Hydrothermal alteration

B) Lawrence, J. R.; Maxwell, S., 1972, Geothermal exploration in the Azores: $^{18}O/^{16}O$ in calcites from volcanic rocks: Journal of Volcanology and Geothermal Research, v. 4, p. 219-223.

C) Purpose: to shed light on the geothermal area of the Azores.

Methods: analysis of oxygen isotope data of calcite from basalt vugs.

Results: oxygen isotope composition of the calcite shows near equilibration with fresh water at observed temperatures only at depth of 600-700 m. This is interpreted to mean that the greatest flow of hot water may occur at that depth interval.

90 . A) Gen. Cat.--Hydrothermal alteration

B) Rass, I. T., 1972, Behavior of the rare-earth elements and yttrium during magmatic metasomatism of ultramafic rocks: Geochemistry International, v. 9, no. 1, p. 68-78.

C) Purpose: examine the partitioning of REE during metasomatism.

Methods: partition chromatography.

Results: Σ REE + Y increases with increasing Na_2O, but decreases as CaO increases, in pyroxene, apatite, melitite, and nepheline in metasomatites. REE distribution reflects variations in pH during alteration; in this case, there was first a decrease in pH and then an increases.

91 . A) Gen. Cat.--Hydrothermal alteration or Behavior of actinides in geomedia

B) Sokolova, N. T.; Acheyev, B. N., 1972, Causes of localization of uranium mineralization in contact-metamorphism aureoles of granitoids: Geochemistry International, v. 9, no. 6, p. 1067-1077.

C) Purpose: determine reasons for zoning of ore minerals around certain intrusions.

Methods: field data, petrography, microprobe.

Results: U-mineralization is associated with intrusions only where alteration is extensive, and in basic sediments and volcanics. Loss of CO_2 and addition of Ca, Fe, and Mg prepares the country rock for mineralization. Later, the rock reacts with hydrothermal solutions rich in U and CO_2, resulting in precipitation of U.

92 . A) Gen. Cat.--Hydrothermal alteration

B) Yes'kova, Y. M.; Yefimov, A. F., 1972, Geochemistry of the rare earths, Sr, and Ba in Ural alkali apoeffusive metasomatites: Geochemistry International, v. 9, no. 5, p. 845-854.

C) Purpose: discuss geochemical trends of REE, Sr, Ba during metasomatism.

Methods: flame photometry; other methods not discussed.

Results: REE are carried in plutonic alkali solutions; their concentrations increase as the grade of metasomatism increases. Concentrations of Sr and Ba either remain the same or decrease as metasomatism progresses. The alkaline earths are residual elements from primary alkali-basaltoids. Elevated Ba and Sr compositions are associated with Ca and the formation of Sr and Ba minerals.

93 . A) Gen. Cat.--Alteration, silica-carbonate

B) Barnes, I.; O'Neil, J. R.; Rapp, J. B.; White, D. E., 1973, Silica-carbonate alteration of serpentine: wall rock alteration in mercury deposits of the California Coast Ranges: Economic Geology, v. 68, no. 3, p. 388-398.

C) Purpose: to determine if CO_2-rich fluids associated with the silica-carbonate rocks are responsible for the silica-carbonate alteration of serpentine.

Methods: petrography, chemical analyses (wet chemistry, AA), XRD, oxygen isotopes, carbon isotopes.

Results: the wall rock alteration processes described are common types of wall rock alterations in mercury mines. The alteration described occurs in acidic solutions. The acidic nature of the solutions at depth is demonstrated by the demonstrated movement of a separate CO_2-rich vapor which requires P_{CO_2} at least equal $P_{hydrostatic}$ at low temperatures.

94 . A) Gen. Cat.--Talc; alteration, ultramafic rocks; saline lake sediments

B) Bricker, O. P.; Nesbitt, H. W.; Gunter, W. D., 1973, The stability of Talc: American Mineralogist, v. 58, no. 1 and 2, p. 64-72.

C) Purpose: to evaluate the thermodynamic stability of talc.

Methods: solubility measurements, enthalpy measurements, heat capacity measurements, and volume measurements.

Results: the ΔG_f^o (25°, 1, talc) value obtained (-1320 kcal) seems to be consistent with observed natural occurrences of talc. Reassessment of the stability of chrysotile ($Mg_3Si_2O_5(OH)_4$), on the basis of talc data, leads to a value of ΔG_f^o (25°, 1, chrys) = -962 kcal.

95. A) Gen. Cat.—Hydrothermal alteration

B) Cox, D. P.; Larson, R. R.; Tripp, R. B., 1973, Hydrothermal alteration in Puerto Rican porphyry copper deposits: Economic Geology, v. 68, no. 8, p. 1329-1334.

C) Purpose: to petrographically observe drill core samples from Puerto Rican porphyry copper and porphyry molybdenum occurrences.

Methods: petrography.

Results: biotitic, propylitic, sericitic, and argillic alterations were observed in the samples. Biotitic alteration is probably the earliest, and the propylitic alteration is the most widespread. Sericitic alteration is generally restricted to envelopes around stage 3 veins cutting rocks with biotitic or propylitic alteration. Supergene argillic alteration is intense in the leached capping and secondary enrichment zones of the deposits.

96 . A) Hydrothermal alteration

B) Dudarev, A. N.; Sotnikov, V. I.; Vasil'yeva, A. I.; Vologdin, N. F.; Shoyekubov, T. S., 1973, Migration of ore components in artificially created thermal gradient field (according to the data of a field experiment): Geochemistry International, v. 10, no. 5, p. 989-999.

C) Purpose: examine redistribution of rock components in a thermal gradient field.

Methods: calorimetry, gas counting, quantitative spectrographic analysis.

Results: prolonged heating (10 days) set up thermal convection fluid systems. Although all mobilized metals participate in the system synchronously, each may create its own subsystem with areas of activation, removal, and deposition. In this case, 2 zones with different transport mechanisms and distribution of metals developed. The zone closest to the heat source (inner zone) exhibits circulation of a water-vapor mixture, has a high concentration of metals in solution, depositing Co, Zn, Cu, and Ni close to the source and Mo and Pb further from the source. The outer zone, characterized by circulation of solution and a lower T than the inner zone, shows the opposite trend in element deposition: Mo and Pb are deposit closer to the heat source, and Co, Zn, Cu, and Ni farther away. Thus, the overall result is a Mo-Pb zone sandwiched between 2 zones comprised of the lighter metals.

97 . A) Gen. Cat.--Alteration, hydrothermal

B) Goosens, P. J.; Hollister, V. F., 1973, Structural control and hydrothermal alteration pattern of Chaucha porphyry copper, Ecuador: Mineralium Deposita, v. 8, no. 4, p. 321-331.

C) Purpose: To describe the structure and alteration of the Chaucha porphyry copper deposit.

Methods: petrography, geologic mapping, soil geochemical surveys, magnetometer survey.

Results: the intrusives and associated volcanic activity, the hydrothermal alteration pattern, and mineralization of the Chaucha porphyry copper deposit appear to be strongly controlled by the intersection of two major structures: the Chaucha fault and the Cordillera fault. Stockwork development and dynamic foliation of the intrusives and surrounding rocks respond to the same control.

98 . A) Gen. Cat.--Hydrothermal alteration

B) Khvostova, V. A.; Poletayev, I. A.; Lipatov, V. N.; Slesarchuk, V. S., 1973, Rare-alkali distributions in unaltered and metasomatized metamorphic rocks: Geochemistry International, v.10, no. 4, p. 923-929.

C) Purpose: examine effects of alteration on rare alkali distribution.

Methods: flame photometry.

Results: unaltered metamorphic rocks are not enriched in rare alkalis. Pegmatite injection led to an order of magnitude increase (from 10ppm to 100ppm) of Li, Rb, and Cs, in the country rock. Post emplacement metasomatism further enriched country rock with rare alkalis. Contacts along granites show no enrichment in rare alkalis. Some biotites in this area contain up to 71,000 ppm Cs. Formation of these biotites occurred about 650 my after pegmatite injection.

99. A) Gen. Cat.--Hydrothermal alteration, biotites

B) Moore, W. J.; Czamanske, G. K., 1973, Compositions of biotites from unaltered and altered monzonitic rocks in the Bingham mining district, Utah: Economic Geology, v. 68, no. 2, p. 269-280.

C) Purpose: to present data on the composition of biotites from unaltered and altered monzonitic rocks in the Bingham mining district, Utah.

Methods: petrography, electron microprobe.

Results: variations in Mg and Fe concentration represent the most significant chemical differences between biotites from unaltered and altered rocks of the Bingham stock. The cationic ratio, 100 Mg:(Mg + Fe) for hydrothermal biotite from the equigranular phase is about 76, compared with a ratio of 64 for biotite from its unaltered equivalent.

100 . A) Gen. Cat.--Hydrothermal alteration

B) Patton, T. C.; Grant, A. R. ; Cheney, E. S., 1973, Hydrothermal alteration of the Middle Fork copper prospect, Central Cascades, Washington: Economic Geology, v. 68, no. 6, p. 816-830.

C) Purpose: to conduct a detailed study of the hydrothermal alteration at the Middle Fork copper prospect.

Methods: geologic mapping, petrography, XRD, chemical analyses (AA, XRF).

Results: the Middle Fork deposit has hydrothermal alteration assemblages similar to southwestern United States porphyry copper deposits, but differs from them in that it 1) occurs in medium-grained quartz dioritic-granodioritic intrusive rocks of batholithic dimensions, 2) has linear, structurally controlled zones of alteration and mineralization, 3) has potassium silicate alteration assemblages remarkably deficient in quartz, 4) lacks a peripheral propylitic zone, 5) contains pyrrhotite as a major sulfide mineral, and 6) has virtually no supergene enrichment.

101. A) Gen. Cat:Hydrothermal alteration

B) Reinking, R. L.; Hilbelink, P. A., 1973, Mineralogy of the altered San Juan Formation at the Idarado Mine, Silverton district, Colorado: Economic Geology, v. 68, no. 3, p. 407-412.

C) Purpose: to describe the vein-related wall rock alteration within the San Juan Formation.

Methods: petrography, XRD.

Results: hydrothermal alteration associated with the vein deposits of the Idarado mine has superimposed on the area-wide propylitic alteration a halo which is sufficiently distinctive to be of use in exploration. In the outer portions of the halow, the patchy development of epidote in plagioclase which characterizes the propylitic zone gives way to increasing intense epidotization, and there is a pronounced increase in the percentage of kaolinite. The central part of the halo is characterized by intense kaolinite and epidote development, with or without an increase in the amount of sericite. Sericite and calcite (plus quartz) are the dominant secondary minerals within a narrow zone adjacent to the veins. Although kaolinite and epidote persist, they do so in decreased amounts.

102. A) Gen. Cat.--Hydrothermal alteration

B) Roberson, C. E.; Schoen, R., 1973, Fluorite equilibria in thermal springs of the Snake River Basin, Idaho: Journal of Research of the USGS, v. 1, no. 3, p. 367-371.

C) Purpose: to determine if fluorite equilibria occurs in some groundwater systems

Methods: chemical precipitation of the mineral components and x-ray diffraction for identification. Solubility products were derived and applied to the samples.

Results: the sampled waters were close to equilibrium with respect to dissolved fluorite.

103. A) Gen. Cat.--Hydrothermal alteration

B) Robinson, B. W., 1973, Sulfur isotope equilibrium during sulfur hydrolysis at high temperatures: Earth and Planetary Letters, v. 18, p. 443-450.

C) Purpose: to examine the possiblity that sulfur hydrolysis mechanism is responsible for the occurrence of at least some of the sulfate found in volcanic thermal waters.

Methods: sulfur and water were heated in sealed tubes and then quenched and sulfur species were separated chemically and analyzed to study the reaction $4S + 4H_2O \rightleftharpoons 3H_2S + HSO_4^- + H^+$ at temperatures between 200 and 320°C.

Results: The isotope exchange reaction: $H_2{}^{18}O + HS^{16}O_4^- \rightleftharpoons H_2{}^{16}O + HS^{18}O_4^-$ is so rapid at the low pH (1.5 - 3) as to be unquenchable. However, the sulfur isotope exchange reaction: $H_2{}^{34}S + H^{32}SO_4^- \rightleftharpoons H_2{}^{32}S + H^{34}SO_4^-$ gave t½ values of 0.1, 0.3, and 1.7 days at 320, 260, and 200°C respectively and equilibrium H_2S-HSO_4^- sulfur isotope fractionation values of 20.9, 22.4, 24.8, 26.7, and 29.3% at 320, 290, 260, 230, and 200°C respectively. The latter data is represented by: $1000 \ln \alpha(HSO_4^- - H_2S) = 5.07\ (10^6 T^{-2}) + 6.33$, and has valuable applications in geothermal and ore deposition studies.

α = fractionation factor

T = temperature °C.

104 . A) Gen. Cat.--Alteration studies

B) Robert, M., 1973, The experimental transformation of mica toward smectite; relative importance of total charge and tetrahedral substitution: Clays and Clay Minerals, v. 21, no. 3, p. 167-174.

C) Purpose: examine alteration by simple transformation in mica minerals.

Methods: XRD.

Results: the main controls on the transformation from mica to vermiculite to smectite are substitution of Si by Al and total charge. Trioctahedral micas, with high tetrahedral Al contents, must have structural modification of tetrahedral layers in order to convert into smectite. Dioctahedral micas have a lower Al content, and lower charge, in the tetrahedral layers, and the transformation can be accomplished by lowering the total charge or oxidizing structural Fe.

105 . A) Gen. Cat.--Alteration, wall rock

B) Rui, I. J., 1973, Structural control and wall rock alteration at Killingdal Mine, Central Norwegian Caledonides: Economic Geology, v. 68, no. 6, p. 859-883.

C) Purpose: to relate the Killindal ore bodies to tectonic structures and wall rock alteration.

Methods: geologic mapping, petrography, chemical analyses.

Results: the close relationship between major and minor tectonic structures and the extremely elongated ore bodies strongly suggests a structural control. Formation of successive quartz-muscovite and chlorite alteration envelopes in the immediate wall rocks, accompanied by extensive redistribution, leaching and introduction of elements from outside, suggests a hydrothermal metasomatic origin of the ores. The ultimate source of the ore-forming solutions is ascribed to metamorphic palingenic processes.

106 . A) Gen. Cat.--Hydrothermal alteration <u>or</u> Behavior of actinides in geomedia

B) Skvortsova, K. V.; Zhil'tsova, I. G.; Karpova, L. N., 1973, Geochemical features of the formation of molybdates and uranomolybdates in the supergene zone: Geochemistry International, v. 10, no. 2, p. 456-463.

C) <u>Purpose</u>: consider associations between molybdates and uranomolybdates with other supergene minerals.

<u>Methods</u>: none discussed.

<u>Results</u>: uranomolybdates form when initial supergene ores contain Mo-sulfides that oxidize at the same rate as uraninite, and when $pH < 7$. At $pH > 7$, uranomolybdates become unstable and are leached out. There are 4 uranomolybdate supergene associations:

1. monrite, iriginite, wulfenite, ferrimolybdite;
2. umohoite, powellite, uranomolybdite;
3. Na-betpakdalite, natrojurosite, goethite, ferromolybdite;
4. casolite, uranophane, wulfenite, calcite.

Major control on supergene associations is pH.

107 . A) Gen. Cat.--Hydrothermal alteration, meteoric waters

B) Taylor, H. P., Jr., 1973, O^{18}/O^{16} evidence for meteoric-hydrothermal alteration and ore deposition in the Tonopah, Comstock Lode, and Goldfield mining districts, Nevada: Economic Geology, v. 68, no. 6, p. 747-764.

C) Purpose: to compare the oxygen isotopes of the Tonopah, Comstock Lode, and Goldfield mining districts with each other.

Methods: oxygen isotopes.

Results: The δO^{18} data conclusively demonstrate that heated meteoric ground waters were dominantly or perhaps wholly the source of the H_2O in the hydrothermal fluids involved in alteration and ore deposition at Tonopah, Goldfield, and the Comstock Lode.

108 . A) Gen. Cat.--Hydrothermal alteration

B) Titley, S. R., 1973, "Pyrometasomatic" - an alteration type: Economic Geology, v. 68, no. 8, p. 1326-1329.

C) Purpose: to suggest that the term "pyrometasomatic" be retained as a description of an alteration type.

Methods: literature review.

Results: field evidence suggests that pyrometasomatic alteration can be developed over a wide range of depth, certainly much more shallow than that indicated for the hypothermal depth zone. Pyrometasomatic alteration seems no more classifiable to a depth zone than is argillic or propylitic alteration.

109 . A) Gen. Cat.--Alteration studies

B) Wenner, D.B.; Taylor, H.P., Jr., 1973, Oxygen and hydrogen isotope studies of the serpentinization of ultramafic rocks in oceanic environments and continental ophiolite complexes: American Journal of Science, v. 273, no. 3, p. 207-239.

C) Purpose: compare D/H and O^{18}/O^{16} values of serpentine from modern ocean environments with ophiolitic serpentine.

Methods: XRD, mass spectrometry.

Results: single ophiolites show a wide variation in ^{18}O; the lowest values occur in the interior, partially altered part. O^{18} data indicate that different types of waters are involved in serpentinization, including meteoric, magmatic, connate, and metamorphic. Most ophiolites were not formed by ocean water, and were thus largely unserpentinized before emplacement on land.

110 . A) Gen. Cat.--Hydrothermal alteration

B) Banks, N. G., 1974, Distribution of copper in biotite alteration products in intrusive rocks near two Arizona porphyry copper deposits: Journal of Research of the USGS, v. 2, no. 2, p. 195-211.

C) Purpose: to discover the relation of Cu content in biotites and their alteration of Cu to S in porphyrys.

Methods: copper and sulfur analysis was made by electron microprobe.

Results: detailed analysis is given. Cu in most chlorites analyzed is concentrated at the optical and chemical boundary of chlorite and biotite and is not associated with sulfur. Other details of Cu occurrence are given.

111 . A)Gen. Cat.--Alteration studies

B) Baweja, A. S.; Wilding, L. P.; McLean, E. O., 1974, Mineralogy and cation exchange properties of Libby vermicultie as affected by particle-size reduction: Clays and Clay Minerals, v. 22, no. 3, p. 253-262.

C) Purpose: determine effects of sample preparation on properties of vermiculite.

Methods: AAS, XRD.

Results: there was no evidence of structural damage due to grinding in particles less than 20 micrometers. Generally, grinding decreased CEC values, probably due to accumulation of biotite. Coarser vermiculite seperates had higher CEC than finer seperates.

112 . A) Gen. Cat.--Alteration studies

B) Foscolos, A. E.; Kodama, H., 1974, Diagenesis of clay minerals from lower Cretaceous shales of northeastern British Columbia: Clays and Clay Minerals, v. 22, no. 4, p. 319-335.

C) Purpose: study effects of burial diagenesis on properties of clays.

Methods: XRD, differential thermal and thermogravimetric analyses, IR spectroscopy, wet chemical methods.

Results: crystallinity index decreases while the sharpness ratio and per cent illite as the 2M polymorph increase with burial depth. K_2O content and ratio of non-hydrated to hydrated clays increase during diagenesis, while surface area and CEC decrease.

113 . A) Gen. Cat.--Alteration studies or Sorption studies

B) Kishk, F. M.; El-Sheemy, H. M., 1974, Potassium selectivity of clays as affected by the state of oxidation of their crystal structure iron: Clays and Clay Minerals, v. 22, no. 1, p. 41-47.

C) Purpose: examine the variation in sorptive properties of a clay with variation in the oxidation state of Fe.

Methods: flame photometry, wet chemical methods.

Results: formation of K-clay from Ca-clay is accompanied by negative ΔG_R, ΔH, and ΔS. Data indicate that K is held more tightly than Ca by the clay. Oxidation of structural Fe increases the K selectivity of the clay and decreases ΔG_R, ΔH, and ΔS for the Ca-K exchange reaction. K is more strongly held by the oxidized than the reduced clay.

114. A) Gen. Cat.--Hydrothermal alteration

B) Moore, W. J.; Nash, J. T., 1974, Alteration and fluid inclusion studies of the porphyry copper ore body at Bingham, Utah: Economic Geology, v. 69, no. 5, p. 631-645.

C) Purpose: to discuss the distribution patterns of biotitic alteration, sericitic alteration, and fluid-inclusion types in igneous host rocks of the Bingham porphyry copper deposit.

Methods: petrography, fluid inclusions.

Results: The distribution of biotitic alteration assemblages and high salinity fluid inclusions generally follows the crudely triangular form of the disseminated copper ore zone. Pervasive sericitic alteration of plagioclase is confined to rocks in the northern one-third of the Bingham stock. The many generations of inclusions trapped from boiling fluids in the temperature range 400°C to 600°C suggest that the system was recharged repeatedly during the period of mineralization.

115 . A) Gen. Cat.--Hydrothermal alteration, granitic rocks

B) Murad, E., 1974, Hydrothermal alteration of granitic rocks and its possible bearing on the genesis of mineral deposits in the Southern Black Forest, Germany: Economic Geology, v. 69, no. 4, p. 532-544.

C) Purpose: to determine variations in the concentration of relevant trace elements in granitic rocks of the southern Black Forest as a function of hydrothermal alteration and mylonitization, with the intention of finding evidence either in favor of or against the lateral secretion hypothesis.

Methods: petrography, chemical analyses (XRF, AA)

Results: leaching of elements, especially lead and zinc, as a result of hydrothermal alteration appears to have been particularly pronounced in the southern Black Forest. This indicates conditions favorable to the formation of ore deposits by lateral secretion in this area.

116. A) Gen. Cat.--Alteration studies

B) Nagasawa, K.; Brown, G.; Newman, A.C.D., 1974, Artificial alteration of biotite into a 14Å layer silicate with hydroxy-aluminum interlayers: Clays and Clay Minerals, v. 22, no. 3, p. 241-252.

C) Purpose: examine the chemistry and kinetics of biotite alteration after boiling in a 0.2M $AlCl_3$ solution.

Methods: XRD, AAS, thermogravimetric analysis.

Results: result of alteration was a 14Å clay mineral with interlayers composed of Al associated with OH and H_2O. The stacking sequence and chemistry of the silicate layers are similar to vermiculite. The basic reaction mechanism is replacement of K by Al, OH, H_2O and oxidation of octahedral Fe.

117. A) Gen. Cat.--Alteration, chromite

B) Onyeagocha, A. C., 1974, Alteration of chromite from the Twin Sisters Dunite, Washington: American Mineralogist, v. 59, no. 5 and 6, p. 608-612.

C) Purpose: to study the behavior of four major elements (Mg, Fe, Al, and Cr) and six minor elements (Ni, Mn, Co, T, Zn, and V) during the alteration of chromite.

Methods: petrography, electron microprobe.

Results: Two types of alteration were recognized in this study. In one, the alteration product is chrome-bearing magnetite which is associated with serpentine. In the other, the alteration product is ferritchromite which is in no way associated with serpentine. Serpentine associated with the magnetite was not studied in detail. Microprobe analyses of chromite, ferritchromite, chromemagnetite, olivine, and chlorite show that the chromite-ferritchronite boundary is sharp (less than 10 microns), and that, relative to chromite, ferritchronite is enriched in Cr, Fe, Ni, and Mn and impoverished in Mg and Al.

118 . A) Gen. Cat.--Alteration studies or Behavior of clays in geomedia.

B) Perry, E. A., Jr.; Turekian, K. K., 1974, The effects of diagenesis on the redistribution of strontium isotopes in shales: Geochimica et Cosmochimica Acta, v. 38, no. 6, p. 929-935.

C) Purpose: explore the effects of diagenesis on the Rb-Sr system.

Methods: XRD, mass spectrometry.

Results: diagenesis results in destruction of detrital mica and feldspar and growth of illite-rich clay from smectite. Increasing diagenesis is accompanied by increasing homogenization with respect to Sr isotopes. The interpretation of Rb-Sr systematics in shale remains uncertain.

119 . A) Gen. Cat.--Hydrothermal alteration

B) Phillips, C. H.; Gambell, N. A.; Fountain, D. S., 1974, Hydrothermal alteration, mineralization, and zoning in the Ray deposit: Economic Geology, v. 69, no. 8, p. 1237-1250.

C) Purpose: to describe the hydrothermal alteration, mineralization, and zoning in the Ray deposit, Pinal County, Arizona.

Methods: drill core studies, chemical analyses, petrography.

Results: hypogene alteration zoning patterns in the Ray deposit are affected by the host rock composition. In the diabase, a biotite-clay zone grades into a chlorite-epidote zone. Sericite and K-feldspar are rare alteration products. Secondary magnetite is common in the high copper zone. In the quartose Precambrian rocks a zone of K-feldspar-biotite alteration occurs in the low sulfide core and in the high copper zone. A sericite zone overlaps the K-feldspar and biotite zone in the high copper zone and decreases outward to the propylitic zone.

120 . A) Gen. Cat.--Alteration, hydrothermal

B) Plimer, I. R., 1974, Pipe-like molybdenite-wolframite-bismuth deposits of Wolfram Camp, North Queensland, Australia: Mineralium Deposita, v. 9, no. 2, p. 95-104.

C) Purpose: to attempt to determine the genesis of some Mo-W-Bi ore-bearing pipes and the chemistry of related wall rock alteration in the light of recent studies of ore deposits associated with granitic rocks.

Methods: petrography, chemical analyses (unspecified), XRD

Results: the alteration was predominantly a base-leaching process at low temperatures and pressures less than .3 kb. Decreasing pH of base-leaching solutions away from the pipes produced major element zoning around the pipes. The pipes are partly located in joints and show an internal zoning of the ore minerals.

121. A) Gen. Cat.--Alteration, hydrothermal

B) Plimer, I. R., 1974, A spessartite-rich alteration assemblage from the Bega Granite, N.S.W., Australia: Lithos, v. 7, p. 43-51.

C) Purpose: to describe the alteration assemblages associated with the Bega granite.

Methods: petrography, chemical analyses (XRF)

Results: it is suggested that the high-level pluton (initially undersaturated with respect to water) underwent alkali metasomatism in its roof zone, followed at lower pressures by the release of aqueous fluids which emplaced ore-bearing quartz-pipes and formed surrounding alteration zones in the metasomatized granitoid. Preferential partitioning of SiO_2, HCl, alkali chlorides, Mo, Mn, Fe, U, and Bi into the aqueous phase is suggested.

122 . A) Gen. Cat.--Hydrothermal effects

B) Ritchie, A. S., 1974, Mercury and antimony complexation under simulated volcanic water conditions: Bulletin Volcanologique, v. 38, no. 4, p. 1090-1094.

C) Purpose: to study the effects on Hg and Sb solutions under volcanic conditions.

Methods: electrophoretic techniques

Results: the formation of anionic chloride complexes is confirmed and for the first time simultaneous formation of cationic hydration complexes is reported.

123 . A) Gen. Cat.--Alteration studies

B) Ross, G. J.; Kodama, H., 1974, Experimental transformation of a chlorite into a vermiculite: Clays and Clay Minerals, v. 22, no. 3, p. 205-211.

C) Purpose: examine whether dehydroxylation of the hydroxide sheet and oxidation of structural Fe in chlorite might result in structural expansion.

Methods: XRD, IR spectroscopy, thermogravimetric and differential thermal analysis.

Results: heating to 610°C and reaction with 0.2 M HCl and 0.2 N NaCl transformed chlorite into a product similar to Kenya vermiculite. Data indicate that the hydroxide sheet must be structurally disturbed before it can be removed. It is likely that oxidation of structural Fe^{2+} plays an important role in initiating structural deformation.

124 . A) Gen. Cat.--Alteration studies

B) Ross, G. J.; Rich, C. I., 1974, Effect of oxidation and reduction on potassium exchange of biotite: Clays and Clay Minerals, v. 22, no. 4, p. 355-360.

C) Purpose: relate changes in K selectivity to changes in oxidation status of octahedral Fe.

Methods: AAS, XRD, IR spectroscopy.

Results: the selectivity of K over Ca of Amelia biotite increased sharply upon oxidation by H_2O_2 at pH = 6. The oxidation caused only a slight loss of Fe and Al (2.8 and 0.4%, respectively) and was only partially reversible. Data indicate that loss of protons from hydroxyls was the mechanism by which charge neutrality was maintained. This process also increases the bond strength of interlayer K, explaining increased K selectivity.

125 . A) Gen. Cat.--Hydrothermal alteration

B) Schmidt, R. G., 1974, Preliminary study of rock alteration in the Catheart Mountain molybdenum-copper deposit, Maine: Journal of Research of the USGS, v. 2, no. 2, p. 189-194.

C) Purpose: to correlate alteration of porphyry rocks and ore occurrence. Methods: major element analysis of rocks and alteration products. Also overall characteristics of alteration products are given. Correlations of alteration and ore occurrence is discussed.

126 . A) Gen. Cat.--Alteration studies

B) Schoen, R.; White, D. E.; Hemley, J. J., 1974, Argillization by descending acid at steamboat springs, Nevada: Clays and Clay Minerals, v. 22, no. 1, p. 1-22.

C) Purpose: describe rock-water reactions at Steamboat Springs.

Methods: XRD, petrography, microprobe, wet chemical methods.

Results: in the shallow subsurface, andesite, granodiorite, and arkosic sediments are altered to kaolinite and alunite; below this, montmorillonite and pyrite are the alteration products. Sulfuric acid, formed by bacterial oxidation of H_2S, is the main alteration agent. Dilution of acid by interaction with the water table coincides with the top of the kaolinite-alunite zone.

127 . A) Gen. Cat.--Alteration studies or Sorption studies

B) Smith, S. J.; Scott, A. D., 1974, Exchangeability of potassium in heated fine-grained micaceous minerals: Clays and Clay Minerals, v. 22, no. 3, p. 263-270.

C) Purpose: examine effects of heating on properties of micaceous minerals.

Methods: wet chemical methods, AES.

Results: heating at 450°C for 24 hours produced a substantial increase in the amount of K first released by the mica in NaCl- Na tetraphenyl boron solutions. The subsequent rate of release varied with the type of mineral. An increase in NH_4 and Cs exchangeability occurred due to the heat treatment.

128 . A) Gen. Cat.--Hydrothermal alteration

B) Steven, T. A.; Luedke, R. G.; Lipman, P. W., 1974, Relation of mineralization to Calderas in the San Juan volcanic field, Southwestern Colorado: Journal of Research of the USGS, v. 2, no. 4, p. 405-409.

C) Purpose: to discover the origin ore mineralization in the caldera field of San Juan Volcanic field, Colorado.

Methods: geologic field relations of alteration mineralization and volcanic rocks are determined.

Results: alteration mineralization is given (ore deposits of lead, zinc, copper, gold and silver) and origins are discussed.

129 . A) Gen. Cat.--Alteration studies

B) Tomita, K., 1974, Similarities of rehydration and rehydroxylation properties of rectorite and 2M clay micas: Clays and Clay Minerals; v. 22, no. 1, p. 79-85.

C) Purpose: describe formation of mixed-layer minerals from mica polymorphs.

Methods: XRD.

Results: a rectorite-type mixed layer mineral was formed from 2M, and 2M$_2$ mica and a random mixed layer mineral was formed from 1M and 1Md mica. The rehydration and rehydroxylation properties of dehydroxylated rectorite and 2M sericites were similar.

130. A) Gen. Cat.--Hydrothermal alteration

B) Tsuzuki, Y.; Mizutani, S.; Shimizu, H.; Hayasahi, H., 1974, Kinematics of alteration of K-feldspar and its application to the alteration zoning: Geochemical Journal, v. 8, no. 1, p. 1-20.

C) Purpose: to experimentally study the alteration of K-feldspar.

Methods: XRD, chemical analyses (AA, flame photometry)

Results: the alteration products comprised kaolinite in general, although sometimes a 12 Å mineral appeared and only amorphous material was observed in strong acid solutions. The rate of reaction depends on the chemical composition of solution and the temperature. On the basis of the experimental results, the alteration process can be expressed by the following rate formula, $\alpha = 1 - \exp(-kt^n)$, where α is the fractional amount of kaolinite in all the minerals present, t is time, and k and n are constants.

131 . A) Gen. Cat.--Alteration studies

B) Ugolini, F. C., 1974, Hydrothermal origin of the clays from the upper slopes of Mauna Kea, Hawaii: Clays and Clay Minerals, v. 22, no. 2, p. 189-194.

C) Purpose: ascertain origin of soils on Mauna Kea, Hawaii.

Methods: AAS, XRD, colorimetry, wet chemical methods.

Results: there are 2 possible origins of these clays: 1) alteration of tephra by steam and water release by melting ice, or, 2) reaction with hypogene fluids.

132 . A) Gen. Cat.--Hydrothermal alteration

B) Vallance, T. G., 1974, Spilitic degradation of a tholeiitic basalt: Journal of Petrology, v. 15, part 1, p. 79-96.

C) Purpose: to analyze spilitic change from a tholeiite basalt from Deccan flow from Bombay India.

Methods: petrography and chemical analysis.

Results: the spilites are secondary products formed from solidified tholeiite by local hydrothermal processes. Chemical and mineralogy is given.

133. A) Gen. Cat.--Alteration, supergene

B) Watmuff, I. G., 1974, Supergene alteration of the Mount Windarra nickel sulfide ore deposit, Western Australia: Mineralium Deposita, v. 9, no. 3, p. 199-121.

C) Purpose: to examine mineralogically the three main zones of alteration as they occur at Mount Windarra in order to formulate a suitable genetic model.

Methods: petrography, drill core studies, XRD, electron microprobe.

Results: three main zones of progressive oxidation, termed the transition, violarite-pyrite and oxide zones, can be delineated in the supergene profile of the Mount Windarra massive-matrix ore deposit. The overall genetic model proposed is electrochemical and is analogous to the corrosion of a piece of metallic iron partially immersed in differentially aerated water.

134 . A) Gen. Cat.--Alteration studies

B) Wenner, D. B.; Taylor, H. P., 1974, D/H and O^{18}/O^{16} studies of serpentinization of ultramafic rocks: Geochimica et Cosmochimica Acta, v. 38, no. 8, p. 1255-1286.

C) Purpose: compare isotope data from several ultramafic bodies in diverse environments.

Methods: XRD, mass spectrometry.

Results: δD values in licordite-chrysotile show a good correlation with geographic position and latitude, paralleling changes in δD of meteoric waters. δO^{18} values are correlative with country rock rather than latitude. The data suggest that serpentinization is accomplished at shallow depths by meteoric hydrothermal water. Isotope data for antigorite bodies indicate genesis during regional metamorphism.

135 . A) Gen. Cat.--Hydrothermal alteration

B) Wollenberg, H. A., 1974, Radioactivity of Nevada hot-spring systems: Geophysical Research Letters, v. 1, no. 8, p. 359-362.

C) Purpose: to measure radioactivity in hot springs and interpret the results.

Methods: field gamma radiometry and laboratory gamma-ray spectrometry.

Results: interpretation of radioactivity readings show high readings primarily from ^{226}Ra and are associated with hot-springs dominated by $CaCO_3$ while silica-dominated systems are relatively low in radioactivity. The reasons for this are discussed.

136 . A) Gen. Cat.--Hydrothermal alteration

B) Abe, H.; Aoki, M., 1975, Experiments on the hydrothermal alteration of mordenite rocks in sodium carbonate solution, with reference to analcimization around Kuroko deposits: Economic Geology, v. 70, no. 4, p. 770-780.

C) Purpose: to estimate the possible conditions of formation of the analcime zone in pyroclastic rocks around Kuroko-type mineral deposits by means of model experiments, in which specimens of mordenite tuff and mordenite-opal tuff were subjected to alteration in sodium carbonate solution, sodium chloride solution, and artificial sea water under hydrothermal conditions.

Methods: XRD, chemical analyses.

Results: experiments indicate that the alkalinity of the reaction solution is a significant controlling factor in analcimization, and that the possible formation temperature of the analcime zone cannot exceed 200°C. It also appears probable that the analcime zone around Kuroko-type mineral deposits is formed by the interaction of an alkaline interstitial solution and the precursor zeolite-bearing acidic pyroclastic rocks.

137. A) Gen. Cat.--Hydrothermal alteration

B) Abrecht, J.; Peters, T., 1975, Hydrothermal synthesis of pyroxenoids in the system $MnSiO_3$ - $CaSiO_3$ at Pf = 2 kb: Contributions to Mineralogy and Petrology, v. 50, p. 241-246.

C) Purpose: to determine the products (experimentally) of (Mn,Ca)-carbonate solid solutions and SiO_2 in CO_2-H_2O mixtures at total pressure of 2 kb.

Methods: synthesis was done in inverted cold seal bombs. X-ray diffraction and IR-spectra were used to determine products.

Results: pyroxenoids on the join $MnSiO_3$-$CaSiO_3$ were synthesized. The type of structure found is mainly dependent on the Mn/Ca ratio and to a lesser extent, on temperature. Compositional trends of the synthesized pyroxenoids is similar to natural pyroxenoids.

138 . A) Gen. Cat.--Hydrothermal alteration

B) Aleksandrov, S. M., 1975, The geochemistry of formation of skarns and ores in the crushed zones of carbonate rocks: Geochemistry International, v. 12, no. 5, p. 2-18.

C) Purpose: illustrate effects of crushed zones on skarn formation.

Methods: literature review.

Results: skarn geochemistry can be greatly determined by tectonic conditions of endogenic mineralization. Tectonic movements can produce pulsating heat flow and metasomatizing solutions, producing rhythmically zoned diffusional skarns. Skarns in crushed zones are extensively greisenized as a result of degassing, but are not subject to early alkali metasomatism.

139 . A) Gen. Cat.--Alteration studies (diagenesis)

B) Berner, R.A., 1975, Diagenetic models of dissolved species in the interstitial waters of compacting sediments: American Journal of Science, v. 275, no. 1, p. 88-96.

C) Purpose: present equations that describe most of the major factors that govern the distribution of dissolved constituents in unconsolidated sediment.

Methods: calculations based on published data.

Results: effects of adsorption (ion exchange) and compaction are considerably more complex than previously recognized. Effects of compaction can be ignored, simplifying the calculations. For strongly adsorbing species, advection should not be ignored.

140 . A) Gen. Cat.—Hydrothermal alteration

B) Bettermann, P.; Liebau, F., 1975, The transformation of amorphous silica to crystalline silica under hydrothermal conditions: Contributions to Mineralogy and Petrology, v. 53, p. 25-36.

C) Purpose: to observe the transformation behavior of different amorphous silicas via cristobalite and keatite to quartz under hydrothermal conditions.

Methods: hydrothermal synthesis were made mainly in the binary system SiO_2-H_2O in a temperature range between 300°C and 500°C and pressures from 0.2 kbar up to 4.0 kbar in cold-seal pressure vessels.

Results: four reaction paths were observed and given. A kinetic model is also given.

141 . A) Gen. Cat.--Hydrothermal alteration

B) Camus, F., 1975, Geology of the El Teniente orebody with emphasis on wall-rock alteration: Economic Geology, v. 70, no. 8, p. 1341-1372.

C) <u>Purpose</u>: to review some geological information on the distribution of wall-rock alteration and its relation to sulfide mineralogy.

<u>Methods</u>: petrography,XRD, differential thermal analysis, chemical analyses.

<u>Results</u>: three hypogene alteration phases and one supergene phase have been recognized in the orebody. The hypogene phases are potassic, quartz-sericitic, and propylitic. The supergene phase is mainly argillic.

142\. A) Gen. Cat.--Zoning, hydrothermal or Hydrothermal alteration

B) Corn, R. M., 1975, Alteration-mineralization zoning, Red Mountain, Arizona: Economic Geology, v. 70, no. 8, p. 1437-1447.

C) Purpose: to present data gathered during an exploration program at Red Mountain.

Methods: geologic mapping, chemical analyses, petrography.

Results: the zoning pattern is characterized by a gradual increase in the grade of copper mineralization with increasing depth, within the zone of weak potassic alteration and the upper part of the potassic alteration zone.

143. A) Gen. Cat.--Hydrothermal alteration

B) Cox, D. P.; González, I. P.; Nash, J. T., 1975, Geology, geochemistry, and fluid-inclusions petrography of the Sapo Alegre porphyry copper prospect and its metavolcanic wallrocks, west-central Puerto Rico: Journal of Research of the USGS, v. 3, no. 3,p. 313-327.

C) Purpose: to describe and determine conditions of formation of the porphyry deposits at the Sapo Alegre prospect, Puerto Rico.

Methods: major element chemistry fluid inclusion analysis, petrography.

Results: alteration zones are analyzed and described as per element variations throughout the zones. Fluid inclusion data suggests temperatures of fluids involved.

144 . A) Gen. Cat.--Alteration, clay minerals

B) Daniel, M. E.; Hood, W. C., 1975, Alteration of shale adjacent to the Knight orebody, Rosiclare, Illinois: Economic Geology, v. 70, no. 6, p. 1062-1069.

C) Purpose: to determine if ore-emplacing brines have caused structural and/or chemical alteration of clay minerals in shale adjacent to the Knight orebody in the Illinois-Kentucky fluorspar district.

Methods: XRD, chemical analyses, petrography.

Results: chemical analyses reveal an increase in magnesium, potassium, and fluorine close to the ore-bearing fault, whereas calcium decreases slightly. Sodium increased in only one small stratigraphic interval, and boron showed no change with relation to the ore.

145 . A) Gen. Cat.--Alteration studies

B) Ewing, R. C., 1975, Alteration of metamict, rare-earth, AB_2O_6-type Nb-Ta-Ti oxides: Geochimica et Cosmochimica Acta, v. 39, no. 4, 521-530.

C) Purpose: examine types and effects of alteration on Nb-Ta-Ti oxides.

Methods: X-ray photography, microprobe analysis.

Results: primary (hydrothermal) alteration causes decreases in U, Th, REE, B-site cations and an increase in Ca and water content. Weathering produces a decrease in Ca and A-site cations and relative increase in B-site cations. R.I., S.G., and reflectance (546 nm) decrease with both types of alteration, while VHN_{50} remains approximately constant.