

INDEX OF AUTHORS

- Appleman, D. E., 31-50
- Bancroft, G. M., 59-66, 137-148
- Bell, P. M., 151-161
- Bonnichsen, B., 217-239
- Boyd, F. R., 211-216
- Brown, G. M., 193-201
- Burns, R. G., 137-148
- Clark, J. R., 31-50, 117-136
- Ernst, W. G., 241-249
- Essene, E. J., 59-65
- Finger, L. W., 95-100
- Ghose, S., 51-58
- Gibbs, G. V., 101-109
- Hafner, S. S., 67-82
- Huckenholtz, H. G., 163-177
- Jaffe, H., 251-274
- Kushiro, I., 179-201
- Lindsley, D. H., 193-201
- Moore, P. B., 111-116
- Mueller, R. F., 83-93
- Muir, I. D., 193-201
- Munoz, J. L., 203-209
- Onuki, H., 241-249
- Papike, J. J., 31-50, 117-136, 275-299
- Robinson, P., 251-274
- Roseboom, E. H., Jr., 151-161
- Ross, M., 275-299
- Schairer, J. F., 163-177
- Schindler, P., 51-58
- Shaw, K. W., 275-299
- Smith, J. V., 3-30
- Virgo, D., 67-82
- Williams, P. G. L., 59-65
- Yoder, H. S., Jr., 163-177

INDEX OF SUBJECTS

- Acmite**, *see also* Aegirine, 163
- chemical analysis, 31, 33
 - crystal structure, 31, 35-48, 40, 41, 42, 43
 - density, 32
 - lattice parameters, 32
 - solid solution with diopside, 175
 - symmetry, 31, 32
 - thermal ellipsoids, 42, 44-45
- Actinolite**,
- cation distribution: 84, 87, 90, 91, 145, 287, 290; Fe-Ca substitution, 64
 - chemical analyses, microprobe, 287, 289
 - chemical formula, 84, 87, 231
 - crystal structure, reference, 98, 117
 - heating experiments, 290-291
 - intergrowths, 275-291, 293-296
 - lattice parameters, 286, 295
 - occurrences: Minn., Biwabik Iron Formation, 218, 231; Montana, Carter Creek iron deposit, 283-284; S. Dak., Black Hills, 293-295
 - phase relations, 290-291, 296
- Activity of**,
- Fe₃O₄, 198
 - H₂O, 200, 232, 259
 - hydrogen, in Skaergaard crystallization, 199
- Activation energy**, 16, 22, 89, 91
- of diffusion processes, orthopyroxenes, 67-68, 77-79
- Aegirine**, *see also* Acmite
- co-existing with: —andradite, 176; —riebeckite, 243-249
 - Mössbauer spectrum, 61-64
 - product of syenitic magmas, 175-176
 - solid solutions with arfvedsonite, riebeckite, 246
 - unmixing, 22
- Äkermanite**, related to leucophane, 115
- Albite**,
- diopside-plagioclase system, 179-190
 - energy of Al-Si exchange, 79
 - lattice parameters, 152
 - melting, in NaAlSi₃O₈-SiO₂ system, 151-161
 - phase relations, 151-161
 - product of low-grade metamorphism, 245
 - stability field, 158, 189
 - X-ray powder data, 152
- Almandine**, 218, 230, 264, 271
- Alteration**, Biwabik Iron Formation, Minn.
- cummingtonite to hornblende, 229-230
 - pyroxene to amphibole, 222, 235-238
- β-Alumina**, 153
- Aluminum**,
- bonding compared: octahedra, 40, 47; tetrahedra, 44, 46, 107, 122, 124-125, 133-134
 - coordination in: —amphiboles, 84, 106, 126-127, 130, 138; —pyroxenes, 35, 40, 47
 - distribution in: —amphiboles, 84, 106, 112-113, 117, 118-119, 133, 139, 140, 141, 145, 229, 231, 232, 235, 261; —pyroxenes, 36, 44-47, 59, 246
 - effect on lattice parameters: clin amphiboles, 128; clinopyroxenes, 47
 - effect on tetrahedral bond distances, 44, 48, 107, 125
 - enrichment in sodic amphiboles and pyroxenes of metamorphic rocks, Calif. and Japan, 246
 - limits imposed by clin amphibole structure, 133
 - partitioning between amphibole and pyroxene, 248-249
 - retention at high pressures, in hornblende, 128
 - thermal ellipsoids, 42, 44-45
 - variation with Fe/Fe + Mg ratio in hornblendes, 232-233
- Analcite**, synthetic, 153, 158
- Andalusite**, 269, 271
- Andradite**,
- in diopside-wollastonite-hematite system, 163-174
 - joins, 170-171
 - lattice parameters, 165-166, 169, 170-171
 - occurrences, 176, 218, 222
 - paragenesis, 176
 - stability field, 169, 170, 173-174, 176
- Ankerite**, 218, 223

Anorthite,

- albite-diopside system, 179, 183–190
- as projection point for “amphibole quadrilateral”, 264
- breakdown reaction, 158, 186
- chemical reactions with diopside: experimental, 183–187; theoretical, 188–190
- stability field, 158
- thermal vibrations, 11, 19

Anthophyllite,

- assemblages, 252, 261, 268, 270
- cation distribution, 90, 145, 291, 293
- chemical analysis, 265
- composition, 272, 293, 294
- crystal structure compared: original determination, 101; relation to primitive cummingtonite, 124–125, 134; relation to protoamphibole, 101, 105
- intergrowth textures, 253, 275, 291–293, 296
- lattice parameters, 101, 292
- occurrence: Mass., N.H., Ammonoosuc volcanic rocks, 252; N.Y., Gouverneur talc schist, 277
- phase relations, 261, 264, 294
- relation to gedrite, 291, 293
- starting material for protoenstatite, 11, 12
- symmetry, 292

Apatite,

- occurrences: Greenland, Skaergaard intrusion, 193; Mass., N.H., Ammonoosuc volcanic rocks, 252; Minn., Biwabik Iron Formation, 218; Montana, Carter Creek iron deposit, 284; Norway, eclogite, 294

Aragonite, transition to calcite, 190**Arfvedsonite,** 246

- crystal structure reference, 117
- riebeckite, stability of aegirine solid solutions, 246

Augite,

- analogy to calcic amphibole, 132
- bonding compared in tetrahedra, 44, 46, 48, 125
- cation distribution, 32, 42–45
- clinohypersthene lamellae, 212–215, 227–228
- crystal structure, 42–45
- density, 32
- intergrowths, 128, 212–215, 227–228
- lattice parameters, 23, 32
- occurrences: 176; Greenland, Skaergaard intrusion, 193; Minn., Biwabik Iron Formation, 219
- symmetry, 31, 32
- thermal expansion, 23, 26
- unmixing, 22–25, 211–215, 227–228
- X-ray powder data, 31, 34

Barium, in joesmithite, 111, 112, 114**Beryl,** related to indialite, 115**Beryllium,**

- effect on amphibole *A* site, 113–114
- in joesmithite, 111–115
- substitution for Si in the amphibole structure, 115

Biotite, occurrences

- Mass., N.H., Ammonoosuc volcanic rocks, 251, 252
- Minn., Biwabik Iron Formation, 218
- Mont., Carter Creek iron deposit, 284
- Norway, eclogite, 294

Bityite, related to muscovite, 115**Bond character,** 36, 42, 47, 54, 64, 99, 107–108, 133**Bond distances,** angles, *see* specific minerals under crystal structure**Bond strength,**

- comparison of Si-O and B-O bonds, 38–39, 42
- discussion: amphiboles, 99, 107–108, 113–114, 134; pyroxenes, 36, 38–39, 41–42, 79

Bonding, *see also* elements, specific minerals,

—discussion,

- amphibole *A* site, 113–115, 128, 129, 132, 134
- amphiboles, 97–99, 104, 107–108, 119–120, 124, 125, 130, 132–133, 134, 242–243
- pyroxenes, 36–42, 44–48, 52, 68
- distortions in coordination polyhedra, 52, 108, 112–115, 119, 124, 125, 130–131, 133

Boron, bond strengths for B-O bonds, 38–39, 42**Bronzite,**

- intergrowths with clinopyroxenes, 20, 212–215
- literature review, 9

Calcite,

- associated with joesmithite, 111
- occurrence, Biwabik Iron Formation, Minn., 218, 230
- transition to aragonite, 190

Calcium,

- coordination in: —clinoamphiboles, 112–114, 119, 126–127, 130; —clinopyroxenes, 35, 38, 41, 43, 46–47, 51–52
- distribution in: —clinoamphiboles, 84, 112–113, 119–121, 124, 128, 129, 130, 132, 134, 229–232, 282–283, 287, 293, 294; —omphacites, 46–47, 48, 59, 64; —pyroxenes during unmixing, 214–215
- effect on: —lattice parameters of clinoamphiboles, 130; —lattice parameters of clinopyroxenes, 47; —tetrahedra in clinopyroxenes, 36–37, 39; —total tetrahedral Al in clinoamphiboles, 133
- thermal ellipsoids, 42, 44–45, 120, 133

Calcium aluminum silicate, $\text{CaAl}_2\text{SiO}_6$, 163**Calcium iron silicate,** $\text{CaFe}_2^{3+}\text{SiO}_6$, 163, 166–170, 174–176**Carnegieite,** *in* $\text{NaAlSi}_3\text{O}_8$ - SiO_2 system, 151**Cation distribution,** intracrystalline,

- determination from bond distances, 43–46, 48, 64, 113, 120, 123, 125, 137
- determination from infrared spectra, alkali amphiboles, 137, 139–140, 141, 144–145
- determination from Mössbauer spectra: alkali amphiboles, 137–138, 140–147; clinopyroxenes, 42–43, 59, 64–65; orthopyroxenes, 67–68, 72–80
- determination from X-ray diffraction analysis: augite, 42–45; crocidolite, 137–138; cummingtonite, 120, 123, 126–127; glaucophane, 126–127, 137–138, 142, 145; grunerite, 96, 99, 120, 126–127; joesmithite 112–115; $\text{LiFe}^{2+}\text{Si}_2\text{O}_6$, 40; omphacites, 43–47; protoamphibole, 102–103, 108
- discussion: clinoamphiboles, 96, 112–115, 119–124, 125, 128–130, 132–133, 134, 139, 144–147, 242–243, 291; pyroxenes, 7, 18, 43–46, 64–65
- effect of pressure: alkali amphiboles, 145; orthopyroxenes, 76
- effect of temperature: alkali amphiboles, 145; orthopyroxenes, 76–77, 79–80, 91; theoretical, 89
- equilibrium of, orthopyroxenes, 67–68, 73–79
- equilibrium isotherms of, orthopyroxenes, 75–76
- indicator of *P-T* conditions, 58, 65, 67–68, 76–77, 79–80, 145
- kinetics and thermodynamics, 67–68, 75–80, 83–92

Cation distribution, intercrystalline,

- amphiboles, 91, 229–232, 261, 275–296
- amphiboles and pyroxenes, 241–249
- pyroxenes, ortho- and clino-, 92, 212–215, 223–224
- theoretical model: 23–24, 91, 92, 246–248; comparison with experimental observations, 24–25, 248–249

Cell dimensions, *see* Lattice parameters**Chalcopyrite,** 218**Chemical analyses,** methods, *see also* Microprobe analyses,

- comparison of results for Fe, 43, 59, 63–65, 137, 142–144, 146
- errors associated with $\text{Fe}^{2+}/\text{Fe}^{3+}$ determination, 143–144, 146, 287
- description for: Calif. and Japan, metamorphic rocks, minerals, 242; Mass., N.H., Ammonoosuc volcanic rock minerals,

- 253, 258; Minn., Biwabik Iron Formation minerals, 220
- Chemical analyses**, results, *see also* Microprobe analyses, and specific minerals,
- Calif. and Japan, metamorphic rocks, minerals, 242–244
- Mass., N.H., Ammonoosuc volcanic rock minerals, 256, 257, 261
- Minn., Biwabik Iron Formation minerals, 221, 223, 224, 231, 233
- orthopyroxenes, 69–70, 214, 221
- Chemical reactions in**
- diopside-plagioclase system, 179–187
- diopside-wollastonite-hematite system, 167–172
- feldspar breakdown, 179
- ferrowollastonite-ferrohedenbergite inversion, 196–201
- layered intrusions, 193–196
- metamorphic: —iron formations, 219–220, 235–238; —mineral assemblages, 272
- quartz-tridymite inversion, 200–201
- spodumene polymorphs — β -quartz_{ss} system, 207
- unmixing of: magnetite from amphiboles and pyroxenes, 287; tremolite and cummingtonite, 282
- Chlorite**, 270,
- occurrences: Calif. and Japan, metamorphic rocks, 242; Minn., Biwabik Iron Formation, 218; Mont., Carter Creek iron deposit, 284
- Chromium**,
- coordination in ureyite crystal structure, 35, 37, 40
- diopside, 58
- distribution in pyroxenes during unmixing, 214
- thermal ellipsoid, 42, 44–45
- Clinoanthophyllite**,
- definition, 279
- nomenclature, 283
- Clinoenstatite**,
- crystal structure: compared, 4, 7, 10–11, 40, 42; reference, 83
- high (β), 4–7, 8, 9, 11
- intergrowths, 16, 227–228
- inversion: 4–7, 8, 13, 16, 224; density reversal, 26–27; with mechanical stress, 5, 21–22
- lattice parameters, 10, 11, 17, 23
- literature review, 4–10, 68
- low (α), 4–7, 8, 10–11
- optical data, 4, 13
- phase relations, 4–7, 18–22, 26–27, 224–225
- symmetry, 11
- thermal expansion, 23, 25–26
- twinning, 4, 8
- X-ray powder data, 4
- Clinoferrosilite**,
- crystal structure compared, 10, 16–18, 42
- Fe-O distance in, 43, 123
- intergrowths, 227–228
- lattice parameters, 11, 17
- literature review, 5, 9–10
- Clinohypersthene**, 19,
- lamellae in augite, 212–215
- Clintonite**, 218
- Coesite**, in NaAlSiO₄-SiO₂ system, 151
- Composition diagrams**,
- amphiboles, 138, 234, 235, 244, 245, 258, 259, 260, 262–278
- pyroxenes, 60, 222, 224
- Compositions of**, *see also* Chemical analyses, results
- co-existing: —amphiboles, 235–236, 281, 293; —amphiboles and pyroxenes, 220–222, 243–245; —pyroxenes, 212–215, 220; —pyroxenes and olivines, 223–224
- garnets in synthetic systems, 164–167, 169, 170–171, 186–188
- synthetic clinopyroxenes, 164–167, 170, 180–187
- Cordierite**,
- assemblages, 261, 264, 268–269, 271
- occurrences: Mass., N.H., Ammonoosuc volcanic rocks, 252; Minn., Biwabik Iron Formation, 218
- Corundum**,
- in spodumene polymorph— β -quartz system, 208
- occurrence, Ammonoosuc volcanic rocks, Mass., N.H., 252
- reactant with plagioclase, 179
- Cosmochlore**, *see* Ureyite
- Cristobalite**, as contaminant in enstatite inversion, 12, 27
- Crocidolite**, *see also* Riebeckite,
- asbestiform, 137
- cation distribution compared, 84, 85, 139–140, 144–145
- chemical analysis, 138, 143
- color and pleochroism, 145–146, 147
- crystal structure reference, 83, 84, 85, 98, 138–139, 243
- infrared spectra, 137, 139–140, 141, 243
- Mössbauer spectra, 140–146
- Crossite**,
- cation distribution, 144–145
- chemical analysis, 138
- color and pleochroism, 145–146, 147
- infrared spectra, 137, 140, 141
- Mössbauer spectra, 137, 140–146
- series with glaucophane, riebeckite, 137, 138, 145
- Crystal structures**,
- discussion: *see also* specific minerals; clinoamphiboles, 119, 130, 132–135, 138; pyroxenes, 4, 7, 8, 10–11, 16–18, 31, 35–49, 79; spodumene polymorphs, synthetic, 203–204
- refinement methods, 13, 14, 31, 33–35, 95–96, 102–103, 111, 117–119
- refinement results: acmite, 35–42, 44–45; augite, 36, 42–46; cummingtonites, 120–127, 130–135; diopside, 35–42, 44–45, 51–52; grunerite, 95–99; hornblende, 121–122, 125–128, 130–134; joesmithite, 112–115; LiFe³⁺Si₂O₆, 35–42, 44–45; omphacites, 36–37, 43–47; protoamphibole, 103–108; protoenstatite, 11–14; richterite, 121–122, 129–134; spodumene, 35–42, 44–45; tremolite, 119–122, 124, 126–127, 130–135; ureyite, 35–42, 44–45
- Cummingtonite**,
- alteration, 222–223, 229–230, 235–238
- assemblages, 91, 219, 252, 264, 268, 270, 276, 283–284
- bonds in tetrahedra compared, 106, 107, 122, 124
- cation distribution: 83, 84, 90, 91, 99, 120–121, 123–124, 130, 132, 134–135, 145, 282; thermodynamic model, 90
- chemical analyses, microprobe, 229–230, 231, 279, 282, 287, 289
- compositional range, 229, 232–236, 264, 293
- crystal structure, 83, 98, 117, 120–125, 126–127, 130–132, 134, 135, 276, 281, 283
- density, 118
- heating experiments, 283, 290–291, 294
- infrared spectra, 120, 124
- intergrowth textures, 222–223, 229–230, 275–296
- inversion, C-centered and primitive, 294
- lattice parameters, 118, 230, 277, 286, 292, 295
- manganoan, 117, 120–121, 123–125, 130, 132, 134–135, 277, 286, 292, 295
- nomenclature, 218, 279, 283
- occurrences: Canada, Labrador, Wabush Iron Formation, 293, 295; Maine, Moxie pluton, 294; Mass., N.H., Ammonoosuc volcanic rocks, 252; Minn., Biwabik Iron Formation, 218, 219, 222, 229–230, 232, 235–238; Montana, Carter Creek iron deposit, 284; N.Y., Gouverneur talc schist, 277; S. Dak., Black Hills, 293–295
- optical properties: 229; luminescence in electron beam, 281
- paragenesis, phase relations, Biwabik Iron Formation, Minn., 219, 232–238
- symmetry, 118, 123–125, 130, 132, 134, 279
- twinning, 229, 230
- unmixing, 123, 253, 275–296

- Datolite**,
—bond character, 108
—related to gadolinite, 115
- Deerite**, 241
- Density**, *see* specific minerals
- Density reversal**, clino- and orthoquensstatite, 26–27
- Diffusion processes for cation distributions in**
—Fe-Mg pyroxenes, 18, 23–25, 67–68, 73–79
—metal alloy systems, 68
—theoretical, 83–92
- Diopside**, 123,
—bonding in octahedra compared, 37, 40, 52
—chemical analysis, 31, 33, 56–57
—chemical reactions with feldspars: 179–190; experimental methods, 180
—chrome-, 58
—co-existing with andradite, 176
—compositions of synthetic ferri-, 164–166
—crystal structure: 4, 7, 11, 31, 38, 101; refinement, 35–42, 43, 44–45, 51–52
—density, 32
—distribution of: —Ca, Mg, 33; —Ti, in synthetic, 49; —trace Mn, by EPR spectra, 51–58
—lattice parameters, 23, 32, 51, 101, 168–169
—occurrences: Mass., N.H., Ammonoosuc volcanic rocks, 252; Minn., Biwabik Iron Formation, 219, 222
—paragenesis of ferri-, 174–176
—phase relations: enstatite, 27, 290; plagioclase, 179–190; wolastonite-hematite, 163–176
—solid solutions: Al and Na, 179, 180–187, 245–246; Fe, 163–176
—symmetry, 31, 32, 51–52, 59, 101
—synthetic Ti, 49
—thermal ellipsoids, 42, 44–45
—thermal expansion, 23, 25
—unmixing, 22–23
- Disorder**, *see* Order-disorder
- Eclogites**, 151,
—Germany, Silberbach, Muehgebirg Massif, 190
—Norway, Eiksundsdal complex, 294–295
- Edenite**, 261
- Electron probe**, *see* Microprobe analyses
- Electron paramagnetic resonance spectra**,
—as technique for distribution study, 83
—method, 53–54
—results, Mn in diopside, 54–58
—theory, 52
- Electron transfer**, alkali amphiboles, 146, 242–243
- Energy**, *see also* Activation energy, Exchange energy, Free energy, Nucleation energy,
—barrier to order in orthopyroxenes, 89
- Enstatite**,
—crystal structure,
 comparison with feldspar, 79
 discussion, 3–4, 10
 original determination, 16, 101
 product of twinning, 16–18
 relationship to:—anthophyllite, 101, 105;—clinopyroxene, 16–18, 40, 42
—density reversal, ortho- and clino-, 26–27
—disorder in, 44
—hydrated, 200
—inversion, 27
—lattice parameters, 11, 12, 17, 101
—meteoritic, 4, 10, 12
—nomenclature, 3
—optical data, 13
—phase relations 4–7, 18–22, 26–27, 272, 290
—polymorphs, 3–28
—reactant with plagioclase, 179
—thermal expansion, 25–26
- D-Enstatite**,
—product of cooling protoenstatite, 20
- γ -Enstatite**, *see* Protoenstatite
- Enthalpy of exchange**, 79, 90
- Entropy of**
—activation, Fe-Mg exchange, orthopyroxenes, 78
—disordering, change in, orthopyroxenes, 91
—mixing, joesmithite, 115
- Epidote**, occurrences,
—Mass., N.H., Ammonoosuc volcanic rocks, 252
—Minn., Biwabik Iron Formation, 218
—Mont., Carter Creek iron deposit, 284
- Epitaxy**, *see* Intergrowths
- α -Eucryptite**, 204
- β -Eucryptite**, 203, 204
- Exchange**,
—Al-Si, in feldspars, 79
—Be for Si, in tremolite, 115
—chemical, between amphibole intergrowths, 275
—Fe-Mg, in orthopyroxenes, 67, 75–80, 89
—ionic, between ferrohypersthene and fluid, 237
—K-Na, in richterites, 129–130, 134
—mechanisms, theoretical, 89
—Mn with Ca and/or Mg, in diopside, 56–58
- Exchange energy**,
—in pyroxenes, 67–68, 75, 77, 79, 84, 89
- Exsolution**, *see* Unmixing
- Fassaite**,
—cation distribution assigned, 32, 36
—crystal structure compared, 31, 36, 44–46
—density, 32
—lattice parameters, 32
—symmetry, 32
- Fayalite**,
—chemical analyses, 223–224
—occurrences: Greenland, Skaergaard intrusion, 194, 196, 198, 200; Minn., Biwabik Iron Formation, 218, 219, 221, 223–224, 225, 229, 230
—plus quartz, phase relations with Ca-poor pyroxenes, 232–238
- Feldspars**, 117, 246,
—activation energies, 79
—bond character, 108
—breakdown reactions, 158, 179
—crystal structure compared, 79
—exchange, K-Na, 129, 134
—exchange energies, Al-Si, 79
—Na contents related to co-existing hornblendes, 261
—occurrences: Greenland, Skaergaard intrusion, 193; Mass., N.H., Ammonoosuc volcanic rocks, 251, 252; Minn., Biwabik Iron Formation, 218; Montana, Carter Creek iron deposit, 284; Norway, eclogite, 294
—phase relations in synthetic systems: $KAlSiO_4$ - SiO_2 , 158; with diopside component, 179, 180–187
—reactant in quartz-tridymite inversion, 200
—unmixing, 24, 25, 290
- Ferrosilite**,
—crystal structure compared, 7, 10, 16, 42, 68
—Fe-O distance in, 43, 123
—lattice parameters, 11, 17
—literature review, 5
—melting, 158
—polymorphs, nomenclature, 3
- Fluorine**,
—effect on amphibole A site, 132
—presence in protoamphibole, 103

- Forsterite**,
—contaminant, in enstatite inversion, 27
—reactant with plagioclase, 179
- Free energy**, 76–79, 89, 90, 246–247
- Fugacity**, oxygen, 198–199, 200
- Gadolinite**, related to datolite, 115
- Garnet**, *see also* specific minerals,
—compositions in synthetic systems, 164–167, 169, 170–171, 186, 188
—lattice parameters, 165–166, 169, 170–171, 186
—occurrences: 176; Calif. and Japan, metamorphic rocks, 242; Mass., N.H., Ammonoosuc volcanic rocks, 251, 252; Minn., Biwabik Iron Formation, 218, 222, 230; Norway, eclogite, 294; with anthophyllites, 261, 264, 269
—phase relations in synthetic systems: diopside-anorthite, 183–186; diopside-anorthite-albite, 186–187; diopside-wollastonite-hematite, 163–167, 168–171
—Ti-rich, 171
- Gedrite**,
—chemical analysis, 256
—composition, 293, 294
—definition, 252–253, 291
—distinction from anthophyllite, 252–253, 291
—intergrowth textures, 253, 275, 291–293, 296
—lattice parameters, 292
—Na in *A* site, 293
—occurrence, Ammonoosuc volcanic rocks, Mass., N.H., 252, 253, 275
—symmetry, 292
- Germanium**,
—substitution for Si, in clinopyroxene structure, 37–38
- Geothermometry**,
—distribution of Fe-Mg: between Ca-clinopyroxene and orthopyroxene, 92; in orthopyroxenes, 67, 76, 80
—distribution of Mn in diopsides, 58
—for pegmatites, based on spodumene, 206
—oxygen isotope fractionation, quartz-magnetite: Biwabik Iron Formation, Minn., 219; Ruby Mountains, Mont., 283, 290
- Glaucophane**, 96, 98, 117,
—assignment of Fe²⁺/Fe³⁺, 59, 139, 142, 144–145
—bonding compared: octahedra, 126–127, 130, 138–139, 246; strengths, 39, 134; tetrahedra, 106, 107, 122, 124
—cation distribution compared, 59, 84, 85, 121, 126–127, 139, 140, 142, 143–145, 246, 261
—chemical analysis, 138, 143–144
—color and pleochroism, 145–146, 147
—crystal structure compared, 84, 85, 121, 130, 138, 146, 243
—density, 118
—infrared spectra, 137, 139–140, 141
—lattice parameters, 118
—Mössbauer spectra, 140–146
—series with crossite, riebeckite, 137, 138, 145
—solid solution of ferro-, limited natural, 245
- Graphite**
—methane buffer, in heating experiments, 290
—occurrence, Biwabik Iron Formation, Minn., 218
- Greenalite**, 218
- Grossular**,
—breakdown product of anorthite, 158
—in diopside-anorthite system, 185–186
—stability field, 188–189
- Grunerite**,
—cation distribution, 96, 99, 126–127, 130
—crystal structure: references, 98, 117; refinement, 95–99, 120–122, 124, 126–127, 130–131
—density, 95, 118
—infrared spectra, 96
—lattice parameters, 95, 118
—Mössbauer spectra, 96
—occurrences: Mass., N.H., Ammonoosuc volcanic rocks, 252; Minn., Biwabik Iron Formation, 218
—symmetry, 95, 118
—thermal ellipsoids, 98–99
- Haradaite**, bond character, 108
- Heating experiments**,
—clinoamphibole intergrowths, 283, 290–291, 294
—diopside, effect on distribution of trace Mn, 56–58
—hypersthene, Fe distribution, reference, 68
—methods, 69, 199–201, 290
—orthopyroxenes: at one atmosphere, 69, 72–77; literature review, 8, 9; under pressure, 69, 73–74, 76
- Hedenbergite**, 163,
—alteration to amphibole, 222, 230–234
—chemical analyses, 220, 223
—inversion from ferrowollastonite: 196–201; chemical reactions 197–200; experimental, 199–201
—Mössbauer spectrum discussed, 64
—occurrences: Greenland, Skaergaard intrusion, 193–198; Minn., Biwabik Iron Formation, 219, 221, 222–223, 224, 225
- Hematite**,
—associated with joesmithite, 111
—differentiation from ferri-diopsides by X-ray powder data, 168
—occurrence, Biwabik Iron Formation, Minn., 218
—solid solutions with diopside plus wollastonite, 163–174, 176
- Hornblende**, 246
—alteration product: 128; Biwabik Iron Formation, Minn., 222, 223, 230–235
—as K-bearing phase at depth, 125, 128
—cation distribution, 121, 125, 128, 130, 134
—chemical analyses 220, 230–232, 233–235
—composition, 293
—coordination of K and Na in the *A* site, 126–128, 131–132, 134
—crystal structure: references, 106, 117; refinement, 117–119, 121–122, 124–128
—intergrowths, 128, 291–296
—lattice parameters, 118, 230, 292, 295
—nomenclature, 218–219
—occurrences: Maine, Moxie pluton, 294, 295; Mass., N.H., Ammonoosuc volcanic rocks, 252, 261, 272; Minn., Biwabik Iron Formation, 218, 219, 222, 229–232; Norway, eclogite, 294
—paragenesis, Biwabik Iron Formation, Minn., 233–235
—role of tetrahedral Al, 106, 125, 128, 133
—symmetry, 118, 253
—unmixing, 128, 229–230, 293–296
- Howieite**, 241
- Hydroxyl ion**, 200,
—effect on amphibole *A* site, 132
—infrared stretching frequency, 137
—in; —joesmithite, 113–114; —riebeckites, 242; —tremolite, 120, 135
- Hypersthene**, 9,
—chemical analyses, 212–215, 220–221,
—crystal structure, discussion, 10, 16, 19, 42, 68
—distribution of Fe-Mg, 44, 68
—equilibrium relationships, 215, 232–235
—intergrowths with clinopyroxene, 212–215, 224–229
—inverted pigeonites, 25, 220–223
—electron-microprobe studies, 212–215, 221
—occurrence, Biwabik Iron Formation, Minn., 218, 219, 220–221, 223
—replacement by amphibole, 235–238
—unmixing, 24–25, 212–215, 224–229

- Igneous rocks**, 175, 176, 217, 219, 261, 294
- Ilmenite**, 176,
—occurrences: Greenland, Skaergaard intrusion, 199; Mass., N.H., Ammonoosuc volcanic rocks, 252
—unmixing from magnetite, 199
- Indialite**, related to beryl, 115
- Indium**,
—closest In-In approach, $\text{NaIn}^{3+}\text{Si}_2\text{O}_6$, 37, 40
—effect on *c*-dimension in clinopyroxenes, 47
- Infrared spectra**
—amphiboles, 91, 96, 120, 124, 139–141, 145, 147, 243
—as technique for cation distribution study, 83, 91, 137
—methods, 137
- Intergrowths**, *see also* specific minerals,
—amphiboles, 229–230, 252, 275–296
—amphibole-pyroxene, 128, 222–223, 230–234
—amphibole-spinel, 286–287, 292
—estimation of relative amounts in individual phases, 253, 279, 287
—pyroxenes, 16–18, 92, 212–215, 224–229
—pyroxene-olivine, 220–221, 223–224
—pyroxene-spinel, 287
—spinel, 199
—talc-pyroxene, 16
- Ionic bonds**, *see* Bond character
- Iron**,
—bonding compared, octahedra, 38, 40, 68, 97, 113–114, 120, 126–127, 130–132
—coordination in pyroxenes, 35, 38, 40
—determination of $\text{Fe}^{2+}/\text{Fe}^{3+}$: 59, 137, 143, 146, 253; comparison of results from different methods, 43–44, 59, 64–65, 142–143, 146, 265
—distribution: amphiboles, 84, 96, 99, 112–113, 120, 123, 126–127, 139, 140, 142, 143–145; pyroxenes, 43–47, 63–65, 68, 72–76, 214
—distribution of, discussion, 128, 129, 130, 144–147, 293
—effect on: bond distances, 168; color and pleochroism of alkali amphiboles, 146–147; lattice parameters, 47, 168, 170, 173; paragenesis of omphacites, 65, 190; stability fields of jadeite, 246; stability field of spodumene, 204
—kinetics of exchange reaction with Mg, in orthopyroxenes, 67–68, 73–80
—Mössbauer spectra, 59–64, 137–138, 140–147, 166
—oxidation state in diopside-wollastonite-hematite system, 164, 166
—partitioning between amphibole and pyroxene, 248–249
—solubility in Ag-Pd alloy, 200
—substitution for
 Al, 204
 Ca, 64
 Mg, 139, 145
 Mg-Si, diopside-wollastonite-hematite system, 163–176
—thermal ellipsoids, 42, 44–45
- Iron formations**,
—color of alkali amphiboles from, 145
—Labrador, Wabush, 283, 295
—Minnesota
 Biwabik, Dunka River area: 217–238, 294–295; geologic setting, 217–218; metamorphism, 219–220; mineralogy, stratigraphy, 218–219
 Gunflint, amphibole intergrowths, 294–295
—Montana
 Ruby Mountain Range, Carter Creek iron deposit, 283–284
—Quebec, Mt. Wright, metamorphosed, 235
—South Dakota, Black Hills, 293–295
- Jadeite**,
—bonding compared, octahedra, 37–38, 40, 130, 246
—crystal structure compared, 31, 33, 35–42, 203
—density, 32
—in $\text{NaAlSi}_3\text{O}_8$ - SiO_2 system, 151–161
—intergrowths in 128
—lattice parameters, 32, 152
—melting, 151–161
—phase relations, 151–161, 179, 180–183, 189–190, 246
—symmetry, 32, 59
—thermal ellipsoids, 42, 44–45
—X-ray powder data, 152
- Jadeite component**, *see* Sodium
- Joersmithite**,
—cation distribution, 111, 112–115
—chemical formula: analysis, 111; structural determination, 112
—crystal structure, 111–115, 132
—lattice parameters, 111
—paragenesis, 111
—symmetry, 111, 132
- Johannsenite**,
—crystal structure compared, 31, 35–42, 52, 115
—density, 32
—lattice parameters, 32
—Mn-O distance in, 123
—symmetry, 32
- Keatite**, related to β -spodumene, 203
- Khoarite**, 171, 173
- Kinetics**,
—of cation exchange in orthopyroxenes, 67–68, 75–80, 83–92
—of inversion, β -spodumene, 205
- Kyanite**,
—breakdown product of anorthite, 158, 186
—in diopside-anorthite system, 185–186, 189, 190
—occurrences, 251, 252, 268, 269
—stability field, 190, 264, 271
—transition to sillimanite, 190
- Lamellae**, *see* Intergrowths
- Lattice parameters**, *see also* specific minerals
—effects due to: *A* site occupant, clin amphiboles, 129, 132; compositional changes, clinopyroxenes, 46–47, 48–49, 167–168; K-Na exchange, richterites, 130, 132; *M*(4) site occupant, clin amphiboles, 130, 132; strain, temperature, Fe-Mg pyroxenes, 22–24; tetrahedral occupant, clin amphiboles, 128
—of: clinopyroxene, synthetic, 168–169, 173, 184–185, 186–187; garnets, synthetic, 165–166, 170–171; omphacites, function of composition, 181–182; pyroxenes, Fe-Mg, literature review 9–10, 11; β -quartz solid solution, 203–204, 206
—use in thermodynamic calculations, 91
- Lawsonite**, 241
- Layered intrusions**,
—Greenland, Skaergaard: 24, 193–200, 211, 226; comparison with Bushveld, South Africa, 193, 198, 215; mineralogy, 193–194
—South Africa, Bushveld, 211
—U.S.A., Montana, Stillwater Complex, 211, 215, 268
- Lead**, in joersmithite, 111–115
- Leucite**, 158
- Leucophane**, related to åkermanite, 115
- Lithium**,
—coordination in pyroxenes, 35, 36, 38–42
—effect on clinopyroxene: lattice parameters, 47; tetrahedra, 40–42, 133
—hydrothermal studies of systems containing, 208
—in protoamphibole structure, 102, 108
—thermal ellipsoids, 42, 44–45
- Lithium dihydrogen citrate**,
—average Li-O distance for octahedrally coordinated Li, 38
- Lithium fluoride**,
—as flux, 26

- in thermal expansion studies, 25
- Lithium fluormica,**
 - coordination compared for K-O, 129
- Lithium iron silicate, $\text{LiFe}^+\text{Si}_2\text{O}_6$**
 - cation distribution, $\text{Fe}^{2+}/\text{Fe}^{3+}$, 31
 - crystal structure, 31, 36, 38–42
 - density, 32
 - lattice parameters, 32
 - symmetry, 31, 32, 39–42
 - synthesis, 32
 - thermal ellipsoids, 42, 44–45
 - X-ray diffraction powder data, 31, 33
- Lithium oxide,**
 - volatility and solubility, 207
- Magnesio-riebeckite, see Riebeckite**
- Magnesium,**
 - coordination in: amphiboles, 97–99, 104, 108, 119–120, 123–124, 126–128, 130–131; octahedra, compared, 104, 130; pyroxenes, 35, 37, 40, 42, 51–52, 68
 - distribution in: amphiboles, 84, 96, 99, 102, 108, 112–113, 119–120, 124, 126–130, 132, 134, 139, 145, 287, 294; pyroxenes, 36–37, 43–46, 48, 59, 64, 67–68, 72–76, 84, 214
 - effect of occupancy in amphibole $M(4)$ site, 124, 130, 134
 - kinetics of exchange reaction with Fe, in orthopyroxenes, 67–68, 73–80
 - partitioning between amphibole and pyroxene, 248–249
 - temperature factor, best isotropic, in tremolite, 119
 - thermal ellipsoid, 44–45, 120, 133
- Magnesium carbonate, 25**
- Magnesium fluoride, 25**
- γ -magnesium silicate, γ - MgSiO_3 , see Protoenstatite**
- Magnetite, 246**
 - associated with joesmithite, 111
 - buffer, with wüstite, 198–199
 - in diopside-wollastonite-hematite system, 163, 164, 167, 169–170
 - inclusions, 199, 287
 - occurrences: Greenland, Skaergaard intrusion, 198, 199; Mass., N.H., Ammonoosuc volcanic rocks, 252; Minn., Biwabik Iron Formation, 218, 219, 223, 229, 230, 231, 236, 238; Montana, Carter Creek iron deposit, 283
 - product of heating experiments, 290–291
 - titaniferous, 176, 198, 199
 - oxygen isotope fractionation, 283, 290
- Manganese,**
 - as indicator of oxidation state in rock, 244–245
 - coordination in: clinoamphiboles, 126–127, 131, 243–244; clinopyroxenes, 35, 37, 51–52, 243–244
 - distribution in: cummingtonites, 120, 123, 126–127, 130, 132, 135, 283; diopside (trace), 56–58; pyroxenes during unmixing, 214
 - effect on: lattice parameters, 47; pigeonite-orthopyroxene inversion, 228–229; symmetry, cummingtonites, 283; wet chemical analyses, silicates, 146
 - electron paramagnetism of, 52–54
 - partitioning between amphibole and pyroxene, 243–245, 248
- Manganese silicate, MnSiO_3 ,**
 - stabilizer in thermal expansion studies, 25
- Melanite, 176**
- Melilite, reactant (plus corundum) with plagioclase, 179**
- Metal alloy systems,**
 - order-disorder compared, 68, 83, 85
- Metamorphic rocks,**
 - Australia, New South Wales, 261
 - Austria, Hartenstein area marbles, 176
 - Finland, Juva, ferri-diopside in limestone, 176
 - Japan, Shikoku, Sanbagawa terrane, Outer Metamorphic Belt, 241–242
 - United Kingdom, the Lizard, Cornwall, 268–269
 - U.S.A., California, Coast Range, Franciscan terrane, 190, 241–242; California, Diablo Range, metagraywackes, 241–242; Connecticut, Middletown Gneiss, 294–295; Massachusetts, Orange, Ammonoosuc volcanic rocks, 251–252, 254–255; Montana, Cherry Creek area, Madison County, 294–295; New England area, Partridge Formation, 251, 291; New Hampshire, Richmond, Ammonoosuc volcanic rocks, 251, 291; New York, Gouverneur talc schists, 276; Vermont, kyanite zone, 251
 - U.S.S.R., Shueretsky District, Kola, 268
- Meteorites,**
 - Bishopville, enstatite from, 10
 - Moore County, pigeonite from, 24
 - Norton, enstatite from, 12
- Micas, 117, 246, see also specific minerals,**
 - associated with sodic amphiboles, pyroxenes, metamorphic rocks, Calif. and Japan, 242
 - bonding compared, tetrahedra, 132–133, 134
 - coordination of K compared with clinoamphiboles, 129, 132, 134
 - exchange of K-Na, 129, 134
 - polytypes, 17
 - stability relative to clinoamphiboles in upper mantle, 129, 134
 - structure, reference, 117
- Microprobe analysis,**
 - acmite crystal, Green River formation, Wyoming, 31, 33
 - associated minerals: Mass., N.H., Ammonoosuc volcanic rocks, 253, 257; Minn., Biwabik Iron Formation, 220–221, 223, 224, 231, 233; Montana, Carter Creek iron deposit, 287, 289; N.Y., Gouverneur talc schist, 279, 281, 282
 - amphiboles, 231, 233
 - diopside crystal, Gouverneur talc schist, N.Y., 31, 33
 - pyroxenes, 69–70, 211–215, 220–221, 223
 - techniques, 211–212, 215
 - ureyite, synthetic crystal, 31, 33
- Milarite, related to osumilite, 115**
- Mineral associations,**
 - Calif. and Japan, metamorphic rocks, 241–242
 - Mass., N.H., Ammonoosuc volcanic rocks, 251–252
 - Minn., Biwabik Iron Formation, 217–219
 - Montana, Ruby Mountains, Carter Creek iron deposit, 283–284
 - N.Y., Gouverneur talc schist, 276
- Minnesotaite, 218**
- Miscibility gaps,**
 - amphiboles, 132, 253, 261, 275, 291
 - pyroxenes, 132, 182, 246
- Molybdenite, 218**
- Mössbauer spectra, calculations, 60–61, 72, 138, 141, 144, 147**
 - for cation distribution, 59, 64–65, 83, 137, 144–146
 - methods, 59–60, 69–72, 137–138
 - results: aegirine-jadeite, 61–65; alkali amphiboles, 140–144; augite, 42–43; omphacites, 59, 61–65; orthopyroxenes, 7, 72–77, 141
 - results compared: amphiboles, 59, 91, 96, 120, 144–146; hedenbergite, 64; wet chemical analyses, 59, 64–65, 146
- Mullite, impurity in spodumene polymorph- β -quartz system, 208**
- Muscovite,**
 - coordination compared for K-O, 129
 - occurrence, Ammonoosuc volcanic rocks, Mass., N.H., 251
 - related to bityite, 115
- Nepheline,**
 - lattice parameters, 152
 - melting, 151–161
 - phase relations, in $\text{NaAlSi}_3\text{O}_8$ - SiO_2 system, 151–161
 - reactant with plagioclase, 179

- X-ray diffraction powder data, 152
- Nomenclature,**
 - clinoanthophyllite, 283
 - cunningtonites, 279, 283
 - enstatite polymorphs, 3
 - gedrite, 252–253, 291
 - spodumene polymorphs, 203–204
 - tirodite, 283
- Nucleation energy of orthopyroxene,**
 - Biwabik Iron Formation, Minn., 228–229
- Olivine,**
 - chemical analyses, 220, 223–224
 - occurrences: 270; Greenland, Skaergaard intrusion, 193, 194, 195, 197, 198, 200; Mass., N.H., Ammonoosuc volcanic rocks, 252; Minn., Biwabik Iron Formation, 217, 219, 223–225
 - site preference of Fe²⁺, 68
- Omphacite,** 96, 294, 295
 - bonding compared, 44–48, 246
 - breakdown pressure, 158
 - cation distribution: Mössbauer spectra, 46, 59–65; X-ray diffraction, 36–37, 43–47, 246
 - chemical analyses, 31, 32, 59–60
 - crystal structure, 31, 33, 36, 37, 42–48, 59
 - definition of “ideal” *P*2, 46, 48
 - density, 32
 - differentiation by X-ray diffraction data, in solid solution series: diopside-jadeite, miscibility gap, 246; diopside-plagioclase, 180–183, 187, 189–190
 - intergrowths in, 128, 294, 295
 - lattice parameters: 32; as function of composition, 181–182
 - paragenesis, 65, 189–190
 - stability fields, 189–190
 - symmetry, 31, 32, 59
- Optical properties, see also specific minerals,**
 - alkali amphiboles, 137, 145–146, 147, 229
 - amphiboles, luminescence in electron beam, 279–281
 - pyroxenes, 9–10, 13, 21, 164
- Order-disorder,**
 - amphiboles, 95, 99, 108, 112–115, 139, 144–145, 147
 - kinetics and thermodynamics; Fe-Mg silicates, 18–23, 67, 68, 74, 75–79; theoretical, 83–92
 - pyroxenes, 3, 43–44, 46, 48, 59, 65, 67–68, 72–80
- Orthoenstatite, see Enstatite**
- Orthoferrosilite, see Ferrosilite**
- Osumilite, related to milarite, 115**
- Paragenesis of**
 - aluminous clinopyroxenes, 246
 - andradite, 176
 - ferri-diopside, 174–176
 - hornblende, 233–235
 - joesmithite, 111
 - omphacites, 65, 189–190
- Pectolite, bond character in, 108**
- Pegmatites,**
 - Al-Ba-tremolite, possible occurrence, 115
 - color of alkali amphiboles from, 145, 146
 - incipient, Biwabik Iron Formation, Minn., 223–224
 - occurrence of magnesioriebeckite in, 137, 140
- Petalite, synthesis, 204**
- Phase relations,**
 - amphiboles: 282, 290–291, 296; discussion, 124, 134
 - Fe-Mg pyroxenes, 4–10, 18–22, 26–27, 69, 224–225
 - inversions: ferrowollastonite to ferrohedenbergite, 196–200; under mechanical stress, 20–22
 - natural occurrences,
 - Mass., N.H., Ammonoosuc volcanic rocks, 264–268
 - Minn., Biwabik Iron Formation, 232–235
 - Mont., Ruby Mountains, 290
 - systems,
 - diopside-plagioclase, 179–190
 - diopside-wollastonite-hematite, 163–176
 - NaAlSiO₄-SiO₂, 151–161
 - pyroxene quadrilateral, 211, 215
 - spodumene polymorphs and β -quartz, 203–209
- Phengite, coordination compared for K-O, 129**
- Piemontite, 241, 244**
- Piezoelectric tests of**
 - omphacite, 31
 - protoamphibole, 102
 - richterite, 129
 - spodumene, 31
- Pigeonite,**
 - analogy to primitive cunningtonite, 130, 132, 282, 296
 - cation distribution compared, 44
 - chemical analysis, microprobe, 213–215, 221
 - crystal structure compared, 7, 42, 83
 - inverted: 11, 24–25, 220–221, 224–229; electron-microprobe studies, 212–215
 - lattice parameters, 23
 - literature review, 7, 9–10
 - manganiferous, Biwabik Iron Formation, Minn., 218, 221–222
 - phase relations, 27, 224–225
 - thermal expansion, 23, 25–26
 - unmixing, 22–25, 212–215, 224–229, 287
- Polymorphism,**
 - Fe-Mg pyroxenes, 3–10, 16–22
 - LiAlSi₂O₆, 203–207
 - micas, 17
 - SiC, 17
- Polysynthetic structures, 16–18, 26**
- Potassium,**
 - coordination with oxygen compared, 126–129, 131–132, 134
 - effect on clinoamphibole: lattice parameters, 129, 130, 132; total tetrahedral Al, 128
 - enrichment in: igneous riebeckites, 246; metacherty sediments, Calif. and Japan, 242
 - exchange with Na, 129–130, 134
 - in: alkaline rocks, 175–176; pyroxenes, 128, 176
- Pressures,**
 - effect on: basaltic or gabbroic rocks, 189; cation distribution, 76, 145
 - for stability fields of: grossular, 189; grossular plus quartz, 189; kyanite, 190; omphacite, 183, 189, 190
 - of breakdown: anorthite, diopside-anorthite system, 186; petalite, 204; β -spodumene solid solution, 205
 - of formation: omphacites in Franciscan formation, Calif., 190; rocks in Skaergaard intrusion, Greenland, 197, 198
 - of inversion, α -quartz to β -quartz, 206
 - of melting, spodumene polymorphs, 205
 - of metamorphism, Ammonoosuc volcanic rocks, Mass., N.H., 251
- Protoamphibole,**
 - bond character, 106–108
 - cation distribution, 108
 - chemical data, 102
 - crystal structure, 101, 103–108
 - density, 102
 - lattice parameters, 101, 102
 - optical data, 102
 - relationship to anthophyllite, 101, 105
 - stacking faults, twinning, 105
 - symmetry, 101, 102
- Protoenstatite,**
 - cooling product of, 6, 20

- crystal structure, 4, 11–16, 101
- inversion, 13, 16, 18–20, 26–27, 224–225
- lattice parameters, 11, 12, 101
- optical data, 13
- symmetry, 11–12
- thermal expansion, 25–26
- X-ray diffraction studies, 4, 11–12
- Protohypersthene**, 8
- Pyrope**, 125
- in diopside-anorthite system, 186, 188–189
- Pyrrhotite**, 218

- Quartz**, 112,
- assemblages including, 199, 219, 232–238, 245, 251, 265–272, 283
- component in synthetic systems: diopside-plagioclase, 179–190; ferrohedenbergite-ferrowollastonite, 197–200; β -spodumene, 206; $\text{NaAlSi}_3\text{O}_8$ - SiO_2 , 151–161
- inversion to tridymite, 193, 194, 196, 197, 200–201
- occurrences: Calif. and Japan, metamorphic rocks, 242, 248; Greenland, Skaergaard intrusion, 194; Mass., N.H., Ammonoosuc volcanic rocks, 251, 252; Minn., Biwabik Iron Formation, 218, 219, 221, 222, 223, 224; Montana, Carter Creek iron deposit, 283; N.Y., Gouverneur talc schist, 277
- oxygen isotope geothermometer 283, 290
- paramorphs after tridymite, 194
- product of: anorthite breakdown, 158, 179, 183–187; heating experiments, amphiboles, 290–291; low-grade metamorphism, 245
- solid solution: in system $\text{NaAlSi}_3\text{O}_8$ - SiO_2 , 154; with diopside and jadeite, 179
- transition to coesite, 154, 158
- thermal expansion, 26
- β -Quartz**
- polymorph of spodumene, 203–204
- solid solution: solubility of Li + Al in, 204; absence in nature, 207; lattice parameters, 204, 206

- Rhodonite**, 218
- Richterite**,
- cation distribution, 126–127, 129
- coordination of A site: 113, 115, 126–127, 129–132, 134
- crystal structure, 117, 121–122, 124, 126–127, 129–134
- density, 118
- exchange of K-Na, 129–130, 134
- lattice parameters, 118, 129, 132
- symmetry, 128
- Riebeckite**,
- bonding compared, 106, 107, 246
- cation distribution, 139–140, 144–145, 246
- chemical analysis: 138, 143, 242–245; tremolite, 293, 295
- color and pleochroism, 145–146, 147
- crystal structure references, 98, 138–139, 243
- infrared spectra, 137, 139–140, 141, 243
- lattice parameters, 295
- Mössbauer spectra, 140–146
- occurrences: Calif. and Japan, metamorphic rocks, 241–242; Canada, Labrador, Wabush Iron Formation, 293, 295; Mont., Carter Creek iron deposit, 283
- series with: glaucophane-crossite, 137, 138, 145; magnesio-riebeckite, 245
- stability of aegirine solid solutions with arfvedsonite, 246
- unmixing, 293, 295
- Rutile**, 252, 292

- Sapphirine**, 146
- Schefferite**, associated with joersmithite, 111
- Schorlomite**, 176
- Serpentine**, occurrences,
- Minn., Biwabik Iron Formation, 218
- N.Y., Gouverneur talc schist, 277
- Siderite**, 218, 223
- Silicon**, 84,
- bonds with oxygen: 39, 44, 46, 48, 97, 104, 105–108, 114, 119, 122, 124–125, 132–133, 134; bridging-nonbridging, 35, 36, 107–108, 115, 133; character, 36, 107–108, 133; discussion, 36–37, 44, 98–99, 105–108, 115, 124–125, 132–133; effect of other cations, 36–37, 39, 99, 133; strengths, 38–39, 41, 42
- internal standard for X-ray diffraction powder measurements, 168, 170, 181
- Si-Si distances in: amphiboles, 97, 104, 106, 122; pyroxenes, 39, 46, 48
- temperature factor, best isotropic, clinopyroxenes, 42, 49
- thermal ellipsoids in: end-member clinopyroxenes, 42, 44–45; grunerite, 98, 99; tremolite, 120, 133
- Silicon carbide**, SiC , 17
- Sillimanite**,
- assemblage, 264, 268, 272
- occurrence, Ammonoosuc volcanic rocks, Mass., N.H., 251, 252
- transition to kyanite, 190
- Site occupancy**, *see* Cation distribution
- Site occupancy refinement**,
- Mössbauer spectral procedures: alkali amphiboles, 137–138, 140–147; omphacite, 60–61; orthopyroxenes, 71–72
- X-ray diffraction procedures: 33, 118; augite, 42–43; chemical constraints, 33, 42–43, 95–96; glaucophane, 138–139, 142; grunerite, 95–96; omphacite, 42–43, 45–46
- Site energetics**, 68
- Skiagite**, 171
- Sodium**,
- coordination in: amphiboles, 84, 126–128, 130–131, 132, 134, 138; pyroxenes, 35, 38–41
- distribution in: amphiboles, 84, 119, 126–128, 129, 130, 261–262; clinopyroxenes, 36–37, 46–47, 48, 49, 59, 64, 214
- effect on: lattice parameters, 47, 130, 132; tetrahedra, clinopyroxenes, 36, 39; total tetrahedral Al, 133
- enrichment in metacherty sediments, Calif. and Japan, 242
- exchange with K, 129–130, 134
- thermal ellipsoids, 42, 44–45
- Sodium fluoride**, 26
- Sodium indium silicate**, $\text{NaIn}^{\text{III}}\text{Si}_2\text{O}_6$,
- crystal structure compared, 31, 35, 37, 40, 41
- density, 32
- lattice parameters, 32
- symmetry, 32
- Sodium iron germanate**, $\text{NaFe}^{\text{III}}\text{Si}_2\text{O}_6$, 37–38
- Sodium metasilicate**, Na_2SiO_3 ,
- bond character and strengths compared, 36, 41
- in diopside-albite system, 181
- α - $\text{Na}_2\text{Si}_2\text{O}_5$** , bond character, 108
- β - $\text{Na}_2\text{Si}_2\text{O}_5$** , bond character, 108
- Spectra**, *see* Electron paramagnetic resonance, Infrared, Mössbauer, Optical properties
- Spene**, 252
- Spinel**,
- energies of Fe^{2+} -Mg exchange in, 79
- enthalpy of Mg-Al exchange in, 79
- intergrowths, 199, 287
- maximum oxygen fugacity for stability, 198
- synthetic MgAl_2O_4 , 154
- Spodumene** (α -Spodumene),
- bonding compared, 36–41, 130
- chemical analysis, 31, 33, 203
- crystal structure, 31, 35–42, 44–45, 203
- density, 32, 204

- lattice parameters, 32, 204, 206
- symmetry, 31, 32, 39–42, 203
- synthesis, 204, 207
- thermal ellipsoids, 42, 44–45
- X-ray diffraction powder data, 31, 33
- Spodumene polymorphs** (β -spodumene, β -quartz_{ss}),
 - absence in nature, 203
 - crystal structures discussed, 203–204
 - density, 204
 - lattice parameters, 204, 206
 - nomenclature, 203–204
 - phase relations, 203–209
 - solid solutions, 203
 - stability, 203–209
 - symmetry, 203–204
 - synthesis, 204–207
 - X-ray diffraction data, 207
- Staurolite**, 146
 - occurrences with quartz, 251, 252, 264, 268–270, 272
- Steatite**, 25
- Stilpnomelane, occurrences**,
 - Calif. and Japan, metamorphic rocks, 242
 - Minn., Biwabik Iron Formation, 218
- Stratiform complex**, *see* Layered intrusion
- Symmetry**, *see also* specific minerals
 - effects of: $M2$ occupant, pyroxenes, 40–42, 47–48; $M(4)$ occupant, amphiboles, 124, 130, 132, 134
 - lowering in clinoamphiboles due to tetrahedral cation ordering, 133
- Talc**,
 - occurrences: Minn., Biwabik Iron Formation, 218; N.Y., Gouverneur talc schist, 277
 - pressure-transmitting medium, 69
 - starting material for protoenstatite, 4, 12, 16
- Temperatures of**
 - breakdown, anorthite, 186
 - density reversal, clino- and orthoenstatite, 26
 - formation: Calif., Franciscan formation, 190; Greenland, Skaergaard intrusion, 197, 198, 199; Minn., Biwabik Iron Formation, 219
 - inversion; cummingtonites, 294; FeSiO₃-MgSiO₃ join, discussion, 27; ferrowollastonite-ferrohedenbergite, 196–199; ortho- to protoenstatite, 26; quartz to tridymite, 200–201; α -quartz to β -quartz, 206; α -spodumene to β -quartz_{ss}, 205–206; α -spodumene to β -spodumene, 204–206
 - melting: mugearites and phonolites, 176; β -spodumene, 205
 - metamorphism: Mass., N.H., Ammonoosuc volcanic rocks, 251; Mont., Ruby Mountains, 283, 290; N.Y., Gouverneur talc schist, 276
 - stability fields: andradite, 170; grossular, 189; omphacite, 183, 189, 190
- Thermal ellipsoids in:**
 - end-member clinopyroxenes, 42, 44–45
 - grunerite, 98–99
 - tremolite, 120, 133, 134–135
- Thermal expansion**, pyroxenes, 22–27
- Thermodynamics**,
 - diopside-jadeite solid solution, 182
 - equilibrium constants, effect of temperature, 75
 - intercrystalline cation distributions, 19–20, 246–248
 - intracrystalline cation distributions, 67–68, 75–80, 83–92
 - melting at high pressures in binary systems, 154–157
 - metamorphic assemblages, 232–235, 270–272
- Thortveitite**, bonds in tetrahedra compared, 107
- Tirodite**, lattice parameters, nomenclature, 283
- Titanium**,
 - effect on: paragenesis, omphacites, 190; wet chemical analyses, silicates, 146
 - garnet, 171
 - in: augite, 32, 36, 214; diopside, 49; fassaite, 32, 36; hornblende, 118, 128
 - partitioning, amphibole—pyroxene, 249
- Tourmaline**, 146
- Tremolite**,
 - associations, 276–277
 - Be analogue, 115
 - bond strengths, 39, 134
 - bonding in octahedra compared, 119, 126, 130–131
 - cation distribution, 119, 126–127, 130
 - chemical analyses: microprobe, 279; wet, 281–282
 - crystal structure: 98, 275–276; original determination, 101, 117; refinement, 119–122, 124, 126–127, 131–133, 134–135
 - density, 118
 - ferro-, in Biwabik Iron Formation, Minn., 231
 - heating experiments, 283
 - intergrowth textures: 275–283; X-ray diffraction studies, 227–279, 281
 - lattice parameters, 101, 118, 277, 295
 - luminescence in electron beam, 279, 281
 - thermal ellipsoids, 120, 133, 134–135
- Tridymite**, 196, inversion to quartz, 193, 194, 196, 197, 200–201
- Tschermak's component**, *see* Aluminum, Iron, Calcium aluminum silicate, Calcium iron silicate
- Twinning in**
 - cummingtonites, polysynthetic, 229, 230
 - Fe-Mg pyroxenes: experimental observations, 19–20, 212; structural considerations, 7, 8, 9
 - protoamphibole, 105
- Unmixing**, 229, *see also* Intergrowths,
 - amphiboles: 123, 229–230, 252, 275–296; heating experiments, 283, 290–291, 294
 - amphibole-pyroxene, 128
 - amphibole-spinel, 287
 - feldspars, 22, 24, 25, 290
 - ilmenite from magnetite, 199
 - pyroxenes, 8–10, 22–25, 72–73, 211–215
 - pyroxene-pyroxenoid, 197, 200
- Unit-cell constants**, *see* Lattice parameters
- Ureyite**,
 - chemical data, 31, 33
 - crystal structure, 31, 35, 39–41
 - density, 32
 - lattice parameters, 32
 - symmetry, 31, 32
 - synthesis, 31, 32
 - thermal ellipsoids, 42, 44–45
- Vesuvianite**, Be-bearing, 115
- Wollastonite**, 176,
 - occurrences: Greenland, Skaergaard intrusion, 193–194; Minn., Biwabik Iron Formation, 218
 - solid solutions: diopside plus hematite, 163–176; in Skaergaard intrusion, 194–199; inversion to hedenbergite, 196–201
- X-ray diffraction powder data**
 - for: albite, 152; augite, 34; Fe-Mg pyroxenes, literature review, 4–6, 9; jadeite, 152; LiFe³⁺Si₂O₆, 31, 33; nepheline, 152; protoenstatite, 4, 11–12, 14; spodumene, 33, polymorphs, 207
 - use to: distinguish spodumene polymorphs, 207; identify phases, 151, 163, 168, 169, 180, 181–184
- X-ray diffraction single-crystal studies**,

- diffuse reflections in: amphiboles, 105–106, 253; pyroxenes, 7, 24, 44
 —intensities, use to determine relative abundance of co-existing phases, 253, 279, 287
 —methods, structural studies, 31, 33–35, 95–96, 102, 111, 117–119
 —photographs of host and lamellar phases, 279–280, 283, 284
 Zussmanite, 241

INDEX OF AUTHORS CITED

- Abrahams, S. C., 95
 Agrell, S. O., 138, 241
 Ahlfeld, F., 138
 Akimoto, S., 5, 8
 Albee, A. L., 244, 251, 270, 271
 Alexander, L. S., 31
 Alfani, M., 163, 176
 Aoki, K. I., 163, 174, 179, 190
 Appleman, D. E., 3, 4, 7, 10, 11, 16, 31, 35, 40, 42, 44, 47, 51, 52, 68, 83, 105, 108, 117, 118, 119, 123, 125, 130, 133, 134, 203, 204
 Ashton, W. H., 118, 276, 279, 282
 Asklund, B., 275, 276
 Atkins, F. B., 213
 Atlas, L., 4, 6, 8, 11, 12, 13, 16, 21, 26, 27, 211

 Bailey, E. H., 242
 Bailey, S. W., 44, 125
 Bakakin, V. V., 37
 Bancroft, G. M., 43, 46, 59, 61, 63, 64, 65, 70, 91, 96, 117, 120, 137, 138, 140, 141, 144, 145, 146, 147
 Banno, S., 68, 86, 91, 241, 243, 248
 Barnes, V. E., 242
 Barrer, R. M., 204
 Barrett, C. S., 21
 Barth, J., 152
 Beatty, L. B., 32, 60, 190
 Beckett, C., 151
 Bell, P. M., 151, 154, 160, 181, 189, 190, 207, 246
 Berman, H., 159
 Bertoldi, G., 117
 Bethke, P. M., 76, 91
 Binns, R. A., 22, 24, 211, 212, 215, 227, 259, 262, 264, 276
 Birch, F., 151, 152, 153, 154, 179, 183
 Birle, J. D., 68
 Biscoe, J., 35
 Blade, L. V., 163, 176
 Bleany, B., 53
 Bloss, F. D., 101, 102
 Boesen, R. S., 163, 175
 Boettcher, A. L., 153, 154, 160, 163
 Bollmann, W., 22
 Bonnicksen, B., 217, 218, 294, 295
 Boole, G., 87
 Borg, I. Y., 4, 31, 138, 145, 241, 245
 Boriani, A., 276
 Boudette, E. L., 294, 295
 Bowen, N. L., 7, 8, 9, 19, 20, 27, 69, 152, 169, 193, 196, 201, 207
 Bown, M. G., 7, 16, 22, 24, 117, 123, 138, 197, 200, 211, 212, 226, 241, 276, 279, 283
 Boyd, F. R., 4, 5, 6, 7, 9, 13, 22, 27, 40, 58, 69, 105, 108, 130, 151, 159, 180, 207, 211, 212, 215, 224, 232, 290
 Boyer, E., 163
 Bragg, W. L., 35, 51, 68, 83, 84, 101
 Brannock, W. W., 32, 60, 170, 190
 Brousse, R., 163, 174
 Brown, G. E., 106, 107, 108
 Brown, G. M., 7, 9, 10, 22, 24, 25, 27, 40, 47, 105, 108, 130, 193, 194, 195, 196, 197, 198, 200, 211, 212, 213, 214, 215, 224, 226
 Brown, W. L., 4, 5, 12, 16, 18, 19, 20, 21, 79, 275, 276
 Buddington, A. F., 198, 199
 Burnham, C. W., 3, 6, 10, 11, 15, 16, 17, 31, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 46, 48, 68, 75, 95, 102, 108, 123, 129, 132, 181, 203, 206, 241, 246, 249
 Burns, R. G., 43, 59, 61, 63, 64, 65, 70, 91, 96, 117, 120, 137, 138, 139, 140, 141, 144, 145, 146, 147, 243, 249
 Busing, W. R., 102, 111
 Butler, J. R., 268, 269

 Callegari, E., 276
 Carmichael, I. S. E., 129
 Carrison, L. C., 4, 5, 200
 Cetlin, B. B., 95
 Chayes, F., 211
 Chesnokov, B. V., 146
 Chesterman, C. W., 54, 241
 Chinner, G. A., 268, 269, 270
 Christensen, A. N., 31, 32, 34, 35, 39, 40, 41
 Clark, J. R., 15, 31, 32, 33, 35, 36, 37, 39, 44, 45, 46, 47, 48, 51, 52, 59, 64, 84, 95, 96, 98, 99, 106, 107, 113, 115, 117, 118, 119, 121, 122, 123, 124, 125, 127, 129, 130, 131, 132, 133, 134, 137, 138, 139, 141, 144, 145, 146, 181, 182, 190, 241, 243, 245, 246, 249, 276, 281, 283, 294
 Clark, S. P., Jr., 168, 181, 184, 185
 Clayton, R. N., 219
 Clifford, T. N., 251, 273
 Cohen, H. M., 159
 Cohen, L. H., 69, 206
 Coleman, L. C., 168, 169
 Coleman, R. G., 32, 60, 190, 241, 242, 243, 245, 246
 Colville, A. A., 98, 106, 107, 117, 129, 137, 241, 243, 246, 249
 Colville, P. A., 245, 258
 Cook, M. I., 171
 Cromer, D. T., 33, 95
 Cruickshank, D. W. J., 36, 102, 107, 108, 133

 Dallwitz, W. B., 8, 9, 10, 20, 27, 224
 Darlow, S. F., 104
 Davis, B. T. C., 6, 7, 181, 211, 246, 290
 Deer, W. A., 193, 196, 203, 204, 242, 244, 246
 Degens, E. T., 163
 De Neufville, J., 168, 181, 184, 185
 De Vore, G. W., 10, 67, 83, 125
 Dienes, G. J., 68, 83
 Dixon, H. R., 295
 Dixon, J., 60
 Dobretsov, N. L., 246
 Dodge, F. C. W., 261, 264
 Donnay, J. D. H., 129, 132
 Dornberg, M. L., 38
 Doyle, P. A., 95
 Duncumb, P., 211
 Durand, J. L., 102

 Eaton, G. P., 295

- Eckermann, H., Von, 163, 176
 Edgar, A. D., 11, 23, 32, 207
 Edwards, J. L., 76, 91
 Emerson, B. K., 254
 Emslie, R. F., 180
 Engel, A. E. J., 276, 281, 282
 Engel, C. G., 276
 England, J. L., 4, 5, 7, 69, 151, 159, 180, 207
 Erickson, R. L., 163, 176
 Ernst, T., 6
 Ernst, W. G., 40, 105, 108, 130, 138, 171, 190, 241, 242, 243, 245, 246, 258
 Eskola, P., 268, 269, 275
 Espenshade, G. H., 294, 295
 Espinosa, G. P., 171
 Essene, E. J., 46, 60, 65, 145, 181, 190, 241, 243, 245, 246
 Eugster, H. P., 198, 199, 290
 Evans, B. J., 54, 67, 68, 70, 72
 Evans, E. H., 171
 Evans, H. T., Jr., 3, 4, 7, 10, 11, 16, 31, 42, 68, 83, 203, 204
 Eyring, H., 89, 90, 91

 Faye, G. H., 146
 Finger, L. W., 33, 45, 95, 96, 117, 118, 119, 120, 121, 122, 124, 126, 131, 211, 283
 Fischer, K. F., 95, 98, 99, 106, 107, 117, 118, 120, 126, 248
 Foster, W. R., 9, 200
 Frechen, J., 163
 Freed, R. L., 31, 32, 34, 35, 39, 40, 41, 52, 115, 123
 Frondel, C., 32, 171
 Fujisawa, H., 5
 Fyfe, W. S., 60, 65, 145, 181, 190, 241, 243, 245, 246

 Gay, P., 7, 16, 22, 24, 197, 200, 211, 212, 226
 Geller, S., 102, 171
 Ghose, S., 3, 7, 10, 42, 44, 51, 54, 56, 67, 68, 70, 72, 73, 75, 80, 83, 84, 90, 91, 92, 95, 96, 98, 99, 106, 107, 117, 118, 119, 120, 121, 122, 124, 126, 128, 131, 137, 144, 145, 248
 Gibbs, G. V., 40, 68, 98, 101, 102, 105, 106, 107, 108, 117, 130, 132, 133, 137, 241, 243, 245, 246, 249
 Gilbert, M. C., 151, 190, 207, 241, 243, 245, 246, 258
 Giletti, B. J., 283
 Gillespie, R. J., 107
 Gittins, J., 163
 Glasstone, S., 89, 90, 91
 Glusker, J. P., 38
 Gold, D. P., 163, 176
 Goldschmidt, V. M., 83
 Goldsmith, J. R., 107
 Green, A. T., 25, 26
 Green, D. H., 8, 9, 19, 20, 27, 160, 224
 Green, J. C., 264
 Green, T. H., 160
 Greig, J., 152
 Griggs, D. T., 4, 5, 21
 Grover, J. E., 68, 248
 Gruverman, I. J., 69
 Gundersen, J. N., 234
 Güssregen, H., 9
 Güven, N., 7, 10, 42, 44, 129, 132

 Hafner, S. S., 3, 7, 18, 51, 54, 56, 59, 67, 68, 70, 72, 73, 75, 76, 80, 90, 91, 92
 Hallimond, A. F., 258, 261
 Hamilton, W. C., 95, 97
 Handin, J., 4
 Hanneman, R. E., 69
 Hanson, A. W., 102
 Hariya, Y., 160, 185, 186

 Hays, J. F., 179, 186, 189
 Hazell, R. G., 31, 32, 34, 35, 39, 40, 41
 Heard, M., 4, 5, 21
 Heinrich, E. W., 283
 Hellner, E., 95, 98, 99, 117, 120, 248
 Henry, N. F. M., 212
 Heritsch, H., 117
 Hess, H. H., 9, 22, 24, 67, 92, 211, 212, 224, 226
 Hess, J. B., 21
 Hey, M. H., 9, 10, 67, 73
 Hietanen, A., 268, 269
 Hlabse, T., 154
 Holm, J. L., 79
 Howie, R. A., 9, 10, 67, 69, 70, 73, 203, 204, 242, 244, 246
 Huckenholz, H. G., 163, 171, 175, 176
 Huebner, J. S., 113, 115, 118, 129, 130, 132
 Hume-Rothery, W., 106
 Hummel, F. A., 5, 8, 25, 26, 27
 Hytönen, K., 176, 179

 Ingram, D. J. E., 53
 Irwin, W. P., 242
 Isaacs, T., 171, 204
 Ito, J., 171
 Ito, K., 69
 Ito, T., 3, 7, 16, 17, 21
 Iwasaki, M., 241, 242, 243, 246

 Jaffe, H. W., 252, 253, 254, 255, 264, 265, 268, 270, 276, 291, 293, 294
 Jambor, J. L., 10
 James, H. L., 283
 Johnson, C. K., 38
 Jones, D. L., 242
 Joswig, W., 108
 Juurinen, A., 176, 270

 Kahler, E., 117
 Kalb, J., 160, 189
 Kalvius, G. M., 70, 72, 75
 Kashkai, M.-A., 163, 176
 Katsura, T., 5, 8
 Kawahara, A., 117
 Kennedy, G. C., 69, 153, 154, 160, 183, 185, 186
 King, B. C., 163, 175, 176
 Klein, C., Jr., 32, 95, 96, 118, 244, 251, 252, 253, 255, 258, 262, 264, 265, 270, 273, 276, 283, 291, 293, 294, 295
 Klement, W., 206
 Kleppa, O. J., 79, 154
 Koltermann, M., 5, 6, 11, 12
 Komada, E., 5, 8
 Koto, K., 4, 7, 10, 16
 Kôzu, S., 22, 23, 25, 26
 Kranck, S. H., 232
 Kretz, R., 67, 92, 265
 Krishna, P., 17
 Krönert, W., 5
 Kuno, H., 6, 7, 8, 9, 27, 224
 Kurtz, S. K., 31
 Kushiro, I., 7, 160, 179, 180, 184, 190, 211, 246
 Kuzel, H. J., 5
 Kuznetsova, I. K., 185

 Laidler, K. J., 89, 90, 91
 Lange, P. A., 5, 6, 12
 Larsen, E. S., 159, 163, 175, 176
 Laves, F., 24, 107
 Leake, B. E., 259, 261
 LeComte, P., 154, 183

- Lee, D. E., 32, 60, 190, 242
 LeMaitre, R. W., 163
 Levy, H. A., 102, 111
 Lewis, J. F., 163, 175
 Liebau, F., 106
 Lindemann, W., 3, 4, 10, 11, 12, 13, 16
 Lindsley, D. H., 5, 6, 8, 69, 160, 180, 193, 196, 198, 199, 200
 Littler, J. G. F., 146
 Lloyd, E., 151
 Loewenstein, W., 107
 Long, J. V. P., 22, 24, 211, 212, 215, 227
 Love, W. E., 38
 Lovering, J. F., 190
 Lundgren, L. W., Jr., 295
 Lupanova, N. P., 163, 176
 Lutch, W. C., 159, 160

 McCallister, R. H., 291
 McCallum, I. S., 92
 McConnell, J. D. C., 79
 MacDonald, G. J. F., 151, 152, 153, 179
 McDonald, W. S., 36, 107
 MacGillavry, C. H., 37, 111, 118
 MacGregor, I. D., 6
 McKee, B., 190
 McKie, D., 79, 138, 241
 Maddock, A. G., 59, 63, 64, 91, 96, 117, 120, 137, 138, 140, 141, 145, 147
 Mann, J. B., 33
 Manning, P. G., 146
 Martin, K. O., 102, 111
 Mason, B., 32, 43, 118, 125
 Matsui, Y., 68, 86, 91, 248
 Matumura, O., 54
 Mays, R. E., 261, 264
 Midgley, M. G., 102
 Minkin, J. A., 38
 Minutti, L., 276
 Miyashiro, A., 241, 242, 243, 244, 246
 Modell, D. I., 16, 68, 101
 Moore, P. B., 68, 111, 112, 132, 133
 Morgan, B. A., 32, 60, 65
 Morimoto, N., 3, 4, 7, 9, 10, 11, 16, 18, 20, 21, 22, 23, 24, 42, 44, 68, 83
 Morse, J. W., 219
 Muan, A., 67, 169, 200
 Mueller, R. F., 67, 68, 74, 75, 77, 83, 86, 91, 92, 235, 248
 Mügge, O., 21
 Muir, I. D., 193, 194, 196, 198, 200, 224
 Müller, K., 163, 176
 Munoz, J. L., 5, 20, 196, 200, 211
 Murray, R. J., 174

 Nafziger, R. H., 67
 Navrotsky, A., 79
 Newton, A., 154
 Newton, M. S., 153, 154, 183
 Newton, R. C., 183, 190
 Nickel, E. H., 146
 Nishikawa, M., 7
 Nissen, H.-U., 22
 Nolan, J., 11, 23, 32

 O'Hara, M. J., 185
 O'Neil, J. R., 219
 Onuki, H., 241, 242, 243, 245, 246
 Orbach, R., 54
 Orville, P. M., 68, 248
 Osborn, E. F., 180, 204
 Oxburgh, E. R., 125

 Pant, A. K., 36, 108
 Papike, J. J., 15, 31, 32, 33, 35, 36, 37, 39, 44, 45, 46, 47, 48, 51, 52, 59, 64, 84, 95, 96, 98, 99, 106, 107, 113, 115, 117, 118, 119, 121, 122, 123, 124, 125, 127, 129, 130, 131, 132, 133, 134, 137, 138, 139, 140, 144, 145, 146, 181, 182, 241, 242, 243, 244, 245, 246, 249, 252, 253, 258, 261, 262, 264, 276, 279, 281, 283, 294
 Patterson, A. L., 38
 Pauling, L., 38, 39, 54, 79, 84, 106, 107, 134
 Paulitsch, P., 117
 Peacor, D. R., 31, 32, 34, 35, 36, 39, 40, 41, 44, 45, 46, 52, 115, 123
 Perrotta, A. J., 4, 5, 6, 7, 8, 9, 27
 Perry, E. C., Jr., 219
 Perry, T. T., 31
 Phillips, B., 169
 Phillips, R., 198
 Pieri, R. De, 171
 Poldervaart, A., 9, 22, 24, 211, 224, 226
 Pollack, S. S., 4
 Posnjak, E., 196, 201
 Powell, H. M., 106
 Prentice, F. J., 137, 139, 140, 144, 145, 243
 Presnall, D. C., 172, 199
 Prewitt, C. T., 15, 31, 32, 33, 34, 35, 36, 38, 39, 40, 41, 44, 46, 48, 106, 108, 117, 132, 181, 203, 241, 246, 248, 249
 Prider, R. T., 117, 118, 129
 Pulfrey, W., 176
 Putman, H. -M., 163, 176

 Quareni, S., 171

 Rabbitt, J. C., 252, 270, 295
 Ramberg, H., 10, 67, 83
 Rankin, G. A., 163
 Reed, S. J. B., 22, 24, 211, 212, 215, 227
 Ribbe, P. H., 11, 19, 106, 107, 108, 129
 Richardson, S. W., 151, 190, 207, 270
 Riechert, L., 117
 Rieck, G. D., 37, 111, 118
 Riecker, R. E., 5
 Rigby, G. R., 25, 26
 Ringwood, A. E., 160
 Robertson, E. C., 151, 152, 153, 179
 Robertson, J. M., 102
 Robie, R. A., 76, 91, 158, 159, 270
 Robinson, P., 251, 252, 253, 254, 255, 264, 265, 268, 270, 273, 276, 291, 293, 294
 Rockett, T. J., 200
 Rogge, G., 11
 Rooney, T. P., 5
 Roseboom, E. H., 154
 Ross, M., 39, 117, 118, 123, 124, 125, 130, 244, 252, 253, 255, 258, 261, 262, 264, 265, 276, 279, 281, 282, 283, 291, 293, 294
 Roy, D., 204
 Roy, R., 159, 204
 Ruble, W. D., 4

 Sabatier, G., 204
 Sahama, T. G., 67
 Sarver, J. F., 5, 8, 25, 26, 27
 Scarfe, C. M., 160
 Ščavničar, S., 204
 Schairer, J. F., 6, 7, 8, 9, 13, 19, 20, 27, 69, 152, 154, 168, 169, 179, 180, 181, 184, 185, 195, 196, 201, 207, 211, 224, 270
 Scharbert, H. G., 176
 Schindler, P., 51
 Schmitt, H. H., 32, 294, 295

- Schreyer, W., 154, 270, 271
 Schröpfer, L., 49
 Schwab, R. G., 6, 7, 9, 26
 Schwartz, C. M., 4, 5
 Schwartz, G. M., 234, 289
 Schwiete, H. E., 5
 Sclar, C. B., 4, 5, 10, 11, 13, 23, 26, 200
 Segeler, C. G., 118, 276, 281
 Segnit, E. R., 172
 Seifert, F., 271
 Seitsaari, J., 275, 276
 Seki, Y., 190, 241, 242, 243, 245, 246
 Shannon, R. D., 106, 108, 248
 Shapiro, L., 170
 Shaw, K. W., 117, 118, 123, 125, 253, 258, 261
 Shell, H. R., 101, 102
 Shendy, G. K., 70, 72, 75
 Shepherd, E. S., 163
 Sherwood, R. C., 171
 Shido, F., 251
 Simpson, E. S. W., 163
 Skinner, B. J., 171, 203, 204, 270
 Skippen, G. B., 290
 Smith, C. H., 10
 Smith, D., 244
 Smith, D. K., 31
 Smith, G. S., 31
 Smith, J. V., 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 16, 18, 19, 20, 21, 23, 26, 27, 40, 44, 56, 58, 67, 68, 69, 70, 73, 101, 105, 108, 125, 130, 154, 183, 190, 275, 276
 Smith, W. L., 118, 276, 279, 282
 Sobolev, N. V., 185
 Soldatos, K., 24
 Solov, eva, L. P., 37
 Starkey, J., 4, 21
 Stepanov, V. G., 51, 52, 53, 54
 Stephenson, D. A., 4, 5, 6, 7, 8, 9, 10, 11, 13, 23, 26, 27, 67, 73
 Stewart, D. B., 35, 203, 204
 Stewart, O. M., 200
 Stone, A. J., 59, 60, 61, 137, 138, 140, 144, 146, 147
 Stout, J. H., 291
 Strens, R. G. J., 96, 120, 137, 145, 146
 Strong, H. M., 69
 Suckow, A., 5
 Suzuki, T., 102
 Swanson, H. E., 171
 Syono, Y., 5, 8

 Tait, D. B., 180
 Takeda, H., 129, 132
 Takéuchi, Y., 108
 Taylor, H. P., Jr., 163, 190, 199
 Thilo, E., 11
 Thompson, J. B., Jr., 68, 248, 251, 259, 264, 271, 273
 Thompson, J. E., 8, 9, 19, 20, 27, 224
 Tilley, C. E., 7, 9, 163, 174, 179, 190, 195, 196, 201, 268, 269
 Tokonami, M., 4, 7, 9, 11, 22, 23, 24
 Torgeson, D. R., 67
 Toulmin, M. S., 76, 91
 Toulmin, P., III, 290

 Trask, N. J., Jr., 251, 273
 Trommsdorff, V., 4, 21, 22
 Turner, F. J., 4, 5, 21, 145
 Turner, P. S., 95
 Turnock, A. C., 196, 198
 Tuttle, O. F., 160, 193, 201
 Tyler, R. C., 163, 175

 Ueda, J., 22, 23, 25, 26

 Van der Helm, D., 38
 Verhoogen, J., 145
 Verma, A. R., 17
 Vernon, R. H., 276
 Vilminot, J. C., 163
 Vincent, E. A., 193, 194, 195, 196, 197, 198, 200
 Vinokurov, V. M., 51, 52, 53, 54
 Virgo, D., 7, 18, 59, 70, 72, 73, 75, 76, 91
 Viswanathan, K., 23, 96
 Von Gehlen, K., 4, 15, 16

 Waber, J. T., 33
 Wager, L. R., 193, 194, 196, 198, 200, 214
 Waldbaum, D. R., 96, 158, 159
 Walitzi, E. M., 117
 Ward, J., 59, 137
 Warner, J., 32, 43
 Warren, B. E., 16, 35, 51, 68, 84, 87, 98, 101, 117
 Waser, J., 107
 Weiblen, P. W., 117, 118, 124, 244, 252, 253, 262, 276, 279, 281
 Wenk, H.-R., 4, 21, 22
 White, A. J. R., 179, 190
 White, D. A., 217, 218
 White, E. A. D., 204
 Whittaker, E. J. W., 47, 83, 84, 98, 106, 117, 130, 137, 138, 139, 144, 145, 241, 242, 243, 246, 249
 Wier, K. L., 283
 Wilkinson, J. F. G., 163, 175
 Williams, E. J., 68, 83
 Williams, H. J., 171
 Williams, P. G. L., 46
 Williams, R. J. P., 146
 Wilson, A. J. C., 105
 Wimmenauer, W., 163, 176
 Winchell, A. N., 258
 Winchell, H., 186
 Winkler, H. G. F., 204
 Wones, D. R., 198, 199
 Wyllie, P. J., 153, 154, 160

 Yagi, K., 163, 175, 246
 Yoder, H. S., Jr., 7, 9, 152, 163, 174, 179, 180, 181, 185, 190, 195, 196, 201, 270
 Yund, R. A., 291

 Zachariasen, W. H., 38, 42
 Zaripov, M. M., 51, 52, 53, 54
 Zoltai, T., 117, 118, 119, 120, 121, 122, 124, 126, 131
 Zussman, J., 3, 31, 35, 98, 117, 203, 204, 242, 244, 246, 248
 Zwart, H. J., 268, 269
 Zyuzin, N. I., 185