

ENCYCLOPEDIA OF EARTH SCIENCES SERIES

# ENCYCLOPEDIA *of* GEOCHEMISTRY

*edited by*

**CLARE P. MARSHALL** *and*  
**RHODES W. FAIRBRIDGE**



KLUWER ACADEMIC PUBLISHERS  
DORDRECHT | BOSTON | LONDON



# Contents

List of Contributors	xix	Argon	18
Preface	xxxiii	<i>Thomas Staudacher</i>	
Acknowledgements	xxxv	$^{40}\text{Ar}/^{39}\text{Ar}$ Dating Method	19
Acid Deposition	1	<i>T. Mark Harrison</i>	
<i>Martin Mihaljević</i>		Arsenic	21
Acids and Bases	2	<i>Jenny G. Webster</i>	
<i>Carl O. Moses</i>		Astatine	23
Actinium	5	<i>Ronald S. Kaufmann</i>	
<i>Cynthia E.A. Palmer</i>		Atomic Absorption Spectrometry	23
Activation Energy, Activation Enthalpy, Activation Volume	5	<i>Philip J. Potts</i>	
<i>Thomas J. Wolery</i>		Atomic Mass Unit, Avogadro Constant and Mole	23
Activity and Activity Coefficients	7	<i>Cesare Emiliani (deceased)</i>	
<i>Thomas J. Wolery</i>		Atomic Number	25
Aluminum	10	<i>Russell S. Harmon</i>	
<i>Philippe Ildefonse</i>		Authigenesis	26
Americium: Element and Geochemistry	10	<i>Rhodes W. Fairbridge</i>	
<i>David R. Janecky, Wolfgang H. Runde and Mary P. Neu</i>		Barium	28
Analysis: Field Methods	11	<i>Kathleen S. Smith</i>	
<i>R.R. Barefoot</i>		Berkelium	29
Analytical Geochemistry	12	<i>Cynthia E.A. Palmer</i>	
<i>Joaquin Ruiz</i>		Beryllium	29
Analytical Techniques	13	<i>Jeffrey G. Ryan</i>	
<i>Philip J. Potts</i>		Biogenic Methane and Gas Hydrate	30
Antimony: Element and Geochemistry	15	<i>Keith A. Kvenvolden</i>	
<i>Virgil W. Lueth</i>		Biogeochemistry	31
Aqueous Solutions	16	<i>John K. Volkman</i>	
<i>Elizabeth A. Burton</i>		Biomarker: Aliphatic	31
		<i>Kenneth E. Peters and Clifford C. Walters</i>	

Biomarker: Aromatic <i>Bernd R. T. Simoneit</i>	33	Carbonate Sediments <i>Abigail M. Smith</i>	73
Biomarker: Assessment of Thermal Maturity <i>Kenneth E. Peters</i>	36	Cerium <i>Scott M. McLennan</i>	75
Biomarker: Coals <i>Matthias Radke</i>	39	Cesium <i>David W. Mittlefehldt</i>	76
Biomarker: Higher Plant <i>Bernd R. T. Simoneit</i>	39	Chelation <i>Richard M. Kettler</i>	76
Biomarkers: Lipid. Bacterial Chemical Fossils <i>Michel Rohmer</i>	40	Chemical Kinetics <i>Youxue Zhang</i>	77
Biopolymers and Macromolecules <i>Claude Largeau</i>	42	Chlorine <i>Ronald S. Kaufmann</i>	80
Bismuth: Element and Geochemistry <i>Virgil W. Lueth</i>	43	Chromium <i>Eugene S. Ilton</i>	81
Black Shales and Sapropels <i>Jan Jehlička</i>	44	Clapeyron's Equation <i>Jae-Young Yu</i>	82
Boron <i>Jugdeep Aggarwal</i>	44	Clay Membranes <i>T.M. Whitworth</i>	83
Bromine <i>Ronald S. Kaufmann</i>	49	Clay Minerals: Ion Exchange <i>T.M. Whitworth</i>	85
Cadmium <i>Kathleen S. Smith</i>	50	Coal: Organic Petrography <i>J.C. Shearer and T.A. Moore</i>	87
Calcium <i>David W. Mittlefehldt</i>	51	Coal: Origin and Diagenesis <i>R.M. Bustin</i>	90
Calcium Carbonate and the Carbonic Acid System <i>Sylvia Frisia</i>	51	Coal: Types and Characteristics <i>T.A. Moore and J.C. Shearer</i>	92
Californium <i>Cynthia E.A. Palmer</i>	57	Coal: Vitrinite Reflectance and Maturity <i>Ralf Littke</i>	96
Calorimetry <i>Charles A. Geiger</i>	58	Cobalt <i>Achim Albrecht</i>	97
Carbon <i>Austin Long</i>	58	Colloids <i>Montserrat Filella and Jacques Buffle</i>	98
Carbon-14 Dating and other Applications in Earth Sciences <i>D. Lal and S. Krishnaswami</i>	59	Complexes <i>Helen Mango</i>	99
Carbon Cycle <i>Peter S. Bakwin</i>	65	Compound-Specific Isotope Analysis <i>Roger E. Summons</i>	100
Carbon Isotopes <i>Juha Karhu</i>	67	Copper <i>Mark A. Williamson</i>	101
Carbonate Compensation Depth <i>Elizabeth A. Burton</i>	73	Cosmic Elemental Abundances <i>D. Lal</i>	102
		Cosmogenic Nuclides <i>Eric Thorson Brown</i>	104



Counters <i>Ernest B. Ledger</i>	108	Eh-pH Relations <i>Richard B. Wanty</i>	183
Critical Points <i>Peter A. Rock and William H. Casey</i>	110	Einsteinium <i>Cynthia E.A. Palmer</i>	187
Crystal Chemistry <i>Dana T. Griffen</i>	110	Electrolyte Theory <i>Thomas J. Wolery</i>	187
Crystal Field Theory <i>Hans Keppler</i>	118	Electron Capture <i>Carla W. Montgomery</i>	189
Crystal Growth <i>Youxue Zhang</i>	120	Electron Microprobe <i>C. Wagner</i>	190
Curium: Element and Geochemistry <i>Wolfgang H. Runde, Mary P. Neu and David R. Janecky</i>	123	Electronegativity <i>Jae-Young Yu</i>	191
Dating Methods <i>Brian D. Marshall</i>	124	Elementary Particles <i>R.K. Varma</i>	193
Debye-Hückel Equation <i>Thomas J. Wolery</i>	124	Elements: Actinide Series <i>Benoît Villemant</i>	195
Diagenesis <i>Uwe Brand, Joan O. Morrison and Ian T. Campbell</i>	126	Elements: Alkali and Alkaline Earth <i>David W. Mittlefehldt</i>	198
Differential Thermal Analysis and Scanning Calorimetry <i>James L. Gooding</i>	131	Elements: Chalcophile <i>H. Palme</i>	204
Diffusion <i>K. Stüwe</i>	133	Elements: Distribution <i>Frederick A. Frey</i>	204
Dolomite and Dolomitization <i>Sylvia Frisia</i>	140	Elements: Halogen <i>Ronald S. Kaufmann</i>	207
Dysprosium <i>Scott M. McLennan</i>	142	Elements: Heat-producing <i>Fernando Bea</i>	208
Earth's Atmosphere <i>M.A.K. Khalil</i>	143	Elements: High Field Strength <i>V.J.M. Salters</i>	209
Earth's Continental Crust <i>Scott M. McLennan and Stuart Ross Taylor</i>	145	Elements: Incompatible <i>W. Ian Ridley</i>	210
Earth's Core <i>William F. McDonough</i>	151	Elements: Lanthanide Series, Rare Earths <i>Scott M. McLennan</i>	211
Earth's Formation and Geochemical Evolution <i>H. Palme</i>	156	Elements: Large-ion Lithophile <i>Roberta L. Rudnick</i>	214
Earth's Mantle Geochemistry <i>W. Ian Ridley</i>	162	Elements: Lithophile <i>H.G. Stosch</i>	214
Earth's Ocean Geochemistry <i>Joris M. Gieskes</i>	168	Elements: Metalloids <i>Graeme E. Batley</i>	215
Earth's Oceanic Crust <i>Michael Perfit</i>	179	Elements: Noble Gases <i>Thomas Staudacher</i>	216
		Elements: Platinum Group <i>Sarah-Jane Barnes</i>	218

Elements: Radioactive <i>Paul R. Dixon</i>	219	Fugacity <i>Uwe Brand and Ian T. Campbell</i>	256
Elements: Siderophile <i>H. Palme</i>	221	Gadolinium <i>Scott M. McLennan</i>	257
Elements: Trace <i>M. Elaine Kennedy</i>	222	Gallium: Element and Geochemistry <i>Erich Schroll</i>	257
Elements: Transition <i>L. Galois and C. Marshall</i>	223	Gas Chromatography–Mass Spectrometry (GS–MS) <i>Andrew T. Revill</i>	259
Enthalpy <i>Carl O. Moses</i>	226	Gas Source Mass Spectrometry <i>I.P. Wright</i>	261
Entropy <i>Carl O. Moses</i>	227	Geoavailability <i>Kathleen S. Smith</i>	262
Epigenesis <i>Vidojko Jović</i>	232	Geochemical Classification of the Elements <i>Scott M. McLennan</i>	263
Equilibrium <i>Heinz Gamsjäger</i>	232	Geochemical Exploration <i>Arthur W. Rose</i>	266
Equilibrium Constant <i>Erich Königsberger</i>	233	Geochemical Reference Materials <i>K. Govindaraju</i>	269
Erbium <i>Scott M. McLennan</i>	236	Geochemical Tectonics <i>Joaquin Ruiz</i>	270
Europium <i>Scott M. McLennan</i>	236	Geochemical Thermodynamics <i>Peter A. Rock and William H. Casey</i>	271
Experimental Mineralogy and Petrology <i>Charles A. Geiger</i>	237	Geochemistry <i>William S. Fyfe</i>	277
Exsolution <i>Jae-Young Yu</i>	239	Geochemistry: Low-temperature <i>Elizabeth A. Burton</i>	280
Fermium <i>Cynthia E.A. Palmer</i>	245	Geochemistry of Sediments <i>Scott M. McLennan and Richard W. Murray</i>	282
Fick's Law <i>Ronald S. Kaufmann</i>	245	Geochronology and Radioisotopes <i>Carla W. Montgomery</i>	292
Fission-track Analysis <i>Charles H. Naeser and Nancy D. Naeser</i>	246	Geologic Time Scale <i>R. Michael Easton</i>	295
Fluid–Rock Interaction <i>William E. Glassley</i>	248	Geothermal Systems <i>Steven W. Lonker</i>	298
Fluids in Volcanic and Plutonic Environments: Evidence From Fluid Inclusions <i>B. De Vivo</i>	250	Geothermometers <i>Maurice Pagel and Pierre Barbey</i>	302
Fluorine <i>Ronald S. Kaufmann</i>	252	Geothermometry and Geobarometry <i>Richard F. Wendlandt</i>	305
Francium <i>David W. Mittlefehldt</i>	253	Germanium: Element and Geochemistry <i>Erich Schroll</i>	307
Free Energy <i>Carl O. Moses</i>	253	Gibbs–Duhem Equation <i>Peter A. Rock and William H. Casey</i>	308

Gold	309	Iron	348
<i>Jenny G. Webster</i>		<i>Mark A. Williamson</i>	
Hafnium	312	Isotope Dilution	353
<i>P. Jonathan Patchett</i>		<i>Carla W. Montgomery</i>	
Helium	312	Isotope Fractionation	354
<i>Thomas Staudacher</i>		<i>Ian D. Clark</i>	
Helium Isotopes	314	Krypton	358
<i>David W. Graham</i>		<i>Thomas Staudacher</i>	
Henry's Law	315	Laboratory Simulations of Oil and Natural Gas Formation	359
<i>Ian T. Campbell and Uwe Brand</i>		<i>J.S. Seewald and T.I. Eglinton</i>	
History of Geochemistry	315	Lanthanum	360
<i>Rhodes W. Fairbridge</i>		<i>Scott M. McLennan</i>	
Holmium	322	Laser Ablation–Inductively Coupled Plasma–Mass Spectrometry	360
<i>Scott M. McLennan</i>		<i>Douglas L. Miles</i>	
Hydrocarbons	323	Lawrencium	362
<i>John K. Volkman</i>		<i>Cynthia E.A. Palmer</i>	
Hydrogen	325	Lead	362
<i>Ronald S. Kaufman</i>		<i>Martin Mihaljević</i>	
Hydrogen Isotopes	326	Lead: Stable Isotopes	363
<i>R.V. Krishnamurthy</i>		<i>Leon E. Long</i>	
Hydrologic Cycle	330	Lipids (Eubacteria and Archebacteria)	368
<i>Ray Kenny</i>		<i>Michel Rohmer</i>	
Hydrothermal Alteration	331	Lithium: Element and Geochemistry	369
<i>Byron R. Berger</i>		<i>Ju-chin Chen</i>	
Hydrothermal Solutions	333	Luminescence	370
<i>Robert J. Bodnar</i>		<i>G. Calas</i>	
Hypogene	337	Lutetium	371
<i>Vidojko Jović</i>		<i>Scott M. McLennan</i>	
Indium: Element and Geochemistry	339	Lutetium–Hafnium Decay System	372
<i>Erich Schroll</i>		<i>P. Jonathan Patchett</i>	
Inductively Coupled Plasma Mass Spectrometry (ICP–MS)	340	Magmatic Processes	373
<i>Fernando Bea</i>		<i>Robert L. Cullers</i>	
Iodine	341	Magnesium	379
<i>Edward C.V. Butler</i>		<i>David W. Mittlefehldt</i>	
Ion Exchange Chromatography	342	Magnetism	379
<i>Peter van Calsteren</i>		<i>Guillaume Morin</i>	
Ion Microprobe	343	Manganese	382
<i>Nobumichi Shimizu</i>		<i>Lloyd M. Petrie</i>	
Ionic Radii	344	Mass Transfer	384
<i>Diana T. Griffen</i>		<i>Ross C. Kerr</i>	
Iridium	347		
<i>R.R. Barefoot</i>			



Mendelevium <i>Cynthia E.A. Palmer</i>	387	Nitrogen <i>A. Hall</i>	426
Mercury <i>Martin Mihaljević</i>	387	Nitrogen Cycle <i>Elisabeth A. Holland</i>	428
Metamorphic Environments: Chemical Mobility <i>D.R. Bowes and J. Košler</i>	389	Nitrogen Isotopes <i>Nathaniel E. Ostrom and Peggy H. Ostrom</i>	431
Meteorites <i>Gregory A. Snyder</i>	395	Nobelium <i>Cynthia E.A. Palmer</i>	434
Micro-Raman Spectroscopy <i>Stephen Roberts</i>	400	Nucleosynthesis <i>J.N. Goswami</i>	434
Mid-Ocean Ridge Basalt (MORB) <i>Anton P. le Roex</i>	401	Nutrients <i>J. Faganeli</i>	437
Mineral Defects <i>Annemarie Meike</i>	401	Occurrence of Organic Facies <i>R. Basil Johns</i>	439
Mineral Genesis <i>Alain J. Baronnet</i>	404	Oil Seeps and Coastal Bitumens <i>Andrew T. Revill</i>	441
Mineralogy <i>William S. Fyfe</i>	409	Oil Shales <i>A.T. Revill</i>	441
Molybdenum <i>A.A. Bookstrom</i>	411	Oil–Oil and Oil–Source Rock Correlation <i>Clifford C. Walters</i>	442
Mössbauer Spectroscopy <i>D.G. Rancourt</i>	413	Oklo Natural Nuclear Reactor <i>Mark J. Rigali and Bartholomew S. Nagy</i> (deceased)	444
Natural Gas <i>Alain Prinzhofer</i>	415	Onuma Diagrams <i>Jean M. Richardson</i>	446
Natural Resources <i>Martin Hale</i>	416	Ore Deposits <i>Martin Hale</i>	447
Neodymium <i>Scott M. McLennan</i>	418	Organic Geochemistry <i>John K. Volkman</i>	453
Neodymium in Igneous Rocks <i>J. Košler</i>	418	Organic Matter in Fossils <i>Stephen A. Macko and Michael H. Engel</i>	456
Neodymium in Sedimentary Rocks <i>Carol D. Frost</i>	421	Organic Matter in Meteorites <i>Scott Messenger</i>	458
Neon <i>Thomas Staudacher</i>	422	Organics: Contemporary Degradation and Preservation <i>Stuart G. Wakeham</i>	458
Neptunium: Element and Geochemistry <i>Wolfgang H. Runde, David R. Janecky and Mary P. Neu</i>	423	Organics: Sources and Depositional Environments <i>Stuart G. Wakeham</i>	460
Neutron Activation Analysis <i>James R. Budahn</i>	424	Osmium <i>John W. Morgan</i>	461
Nickel <i>Laurence Galois</i>	425	Oxidation–Reduction <i>Charles G. Patterson</i>	462
Niobium <i>A.M.R. Neiva</i>	426		

Oxygen <i>Steven C. Semken</i>	467	Phosphorus <i>Gerald Matisoff</i>	516
Oxygen Isotopes <i>Ethan L. Grossman</i>	469	Platinum <i>W. Crawford Elliott</i>	516
Paleo-Sea Surface Temperature Estimations: Organic Geochemistry and Paleoclimates <i>Elisabeth L. Sikes</i>	475	Plutonium: Environmental Chemistry and Geochemistry <i>Paul R. Dixon and David B. Curtis</i>	517
Paleoenvironments <i>M. Elaine Kennedy</i>	477	Polonium: Element and Geochemistry <i>Wolfgang H. Runde</i>	518
Paleoproductivity <i>Uwe Brand, Ian T. Campbell and Joan O. Morrison</i>	479	Porphyryns <i>Chris Boreham</i>	519
Paleotemperature <i>Uwe Brand, Joan O. Morrison and Ian T. Campbell</i>	480	Potassium <i>David W. Mittlefehldt</i>	522
Palladium <i>Christopher J. Capobianco</i>	484	Potassium-Argon Dating Method <i>K.A. Foland</i>	522
Paragenesis <i>Robert J. Kamilli</i>	485	Potassium-Calcium Decay System <i>Brian D. Marshall</i>	525
Particle-Induced X-Ray Emission (PIXE) <i>J.L. Campbell</i>	488	Praseodymium <i>Scott M. McLennan</i>	526
Partition Coefficients <i>Robert L. Cullers</i>	489	Precambrian Atmosphere <i>Grant M. Young</i>	526
Peat <i>William Shotyk</i>	490	Precambrian Geochemistry <i>R. Michael Easton</i>	532
Periodic Table <i>Gregory A. Snyder</i>	491	Precambrian Organic Matter <i>Roger E. Summons</i>	535
Petroleum <i>R.G. Schaefer</i>	494	Promethium <i>Scott M. McLennan</i>	537
Petroleum: Hydrothermal <i>Bernd R.T. Simoneit</i>	497	Protactinium <i>David A. Pickett</i>	537
Petroleum: In-reservoir Biodegradation <i>Jacques Connan</i>	498	Quantum Numbers <i>D. G. Rancourt</i>	539
Petroleum: Kinetic Modeling <i>R.G. Schaefer</i>	499	Radioactivity <i>Stephen A. Prevec</i>	540
Petroleum: Primary Migration (Generation and Expulsion) <i>Jean Burrus</i>	500	Radium <i>Arthur W. Rose</i>	541
Petroleum: Surface Geochemistry <i>R.P. Philp</i>	502	Radon <i>Arthur W. Rose</i>	542
Petroleum: Types, Occurrence and Reserves <i>R.G. Schaefer and D.H. Welte</i>	504	Rare Earth Element Tetrad Effect <i>T. Akagi</i>	543
Phase Equilibria <i>Robert W. Luth</i>	505	Remote Sensing <i>David A. Rothery</i>	544
		Rhenium <i>John W. Morgan</i>	547



Rhenium–Osmium Dating Method <i>John W. Morgan</i>	547	Stable Isotopes <i>Ian D. Clark</i>	588
Rhodium <i>R.R. Barefoot</i>	550	Standard States <i>Peter A. Rock and William H. Casey</i>	592
Rock-Eval Pyrolysis <i>Kenneth E. Peters</i>	551	Steroidial Compounds <i>John K. Volkman</i>	593
Rocks <i>Vidojko Jović</i>	554	Stoichiometry <i>R. Hellmann</i>	595
Rubidium: Element and Geochemistry <i>E. Craig Simmons</i>	555	Strontium: Element and Geochemistry <i>E. Craig Simmons</i>	598
Rubidium–Strontium Method <i>Leon E. Long</i>	556	Strontium in Igneous Rocks <i>Jon Davidson</i>	599
Ruthenium <i>R.R. Barefoot</i>	561	Strontium in Sedimentary Rocks <i>Uwe Brand, Joan O. Morrison and Ian T. Campbell</i>	600
Samarium <i>Scott M. McLennan</i>	563	Sulfate Minerals <i>Jeremy P. Richards</i>	603
Samarium–Neodymium <i>Carla W. Montgomery</i>	563	Sulfate Reduction <i>Hans G. Machel</i>	603
Sampling <i>Jean M. Richardson</i>	567	Sulfide Minerals <i>Jeremy P. Richards</i>	605
Scandium <i>Scott M. McLennan</i>	569	Sulfides in Mafic and Ultramafic Magmas <i>Robert D. Francis</i>	606
Scanning Electron Microscope <i>C. Wagner</i>	569	Sulfosalt Minerals <i>Jeremy P. Richards</i>	607
Sedimentary Fluids <i>Ian E. Hutcheon</i>	570	Sulfur <i>Martin A.A. Schoonen</i>	608
Selenium <i>Eugene S. Ilton</i>	571	Sulfur Cycle <i>Martin A.A. Schoonen</i>	608
Silicon, Silica <i>Nancy W. Hinman</i>	572	Sulfur Isotopes in Geochemistry <i>Keith Hannan</i>	610
Silver: Element and Geochemistry <i>Helen N. Mango</i>	576	Supergene <i>Vidojko Jović</i>	615
Sodium <i>David W. Mittlefehldt</i>	578	Surface Geochemistry <i>Christian Ludwig and William H. Casey</i>	616
Soil <i>William S. Fyfe</i>	578	Synchrotron X-Ray Fluorescence Analysis <i>Philip J. Potts</i>	617
Solid Solution <i>Erich Königsberger</i>	580	Syngeneis <i>Rhodes W. Fairbridge</i>	618
Solubility <i>Heinz Gamsjäger</i>	583	Tantalum <i>A.M.R. Neiva</i>	620
Spectrophotometry <i>Ian T. Campbell and Uwe Brand</i>	587	Technetium: Environmental Chemistry and Geochemistry <i>Paul R. Dixon and David B. Curtis</i>	621

Tellurium <i>Vidojko Jović</i>	621	Van der Waals Force <i>Jae-Young Yu</i>	655
Terbium <i>Scott M. McLennan</i>	622	Vanadium <i>Gregory A. Snyder</i>	656
Thallium <i>Vidojko Jović</i>	622	Volcanic Gases <i>T.M. Gerlach</i>	656
Thermal Ionization Mass Spectrometry <i>Peter van Calsteren</i>	623	Volcanism <i>Peter W. Francis</i>	658
Thermochemistry <i>Mitchell Schulte</i>	624	Water <i>Carl O. Moses</i>	660
Thermogravimetry <i>Patrick K. Gallagher</i>	626	Water: Fresh <i>Arthur H. Brownlow</i>	667
Thermoluminescence <i>Christophe Falguères</i>	628	Weathering: Chemical <i>Patrick V. Brady</i>	668
Thixotropy <i>H.C. Weed</i>	630	X-Ray Diffraction <i>R.J. Angel</i>	670
Thorium: Element and Geochemistry <i>S. Krishnaswami</i>	630	X-Ray Fluorescence Analysis <i>Philip J. Potts</i>	670
Thulium <i>Scott M. McLennan</i>	635	Xenon <i>Thomas Staudacher</i>	671
Tin <i>A.M.R. Neiva</i>	635	Ytterbium <i>Scott M. McLennan</i>	673
Titanium: Element and geochemistry <i>François Farges</i>	636	Yttrium <i>Scott M. McLennan</i>	673
Trace Element Partitioning Models <i>Roger L. Nielsen</i>	637	Zinc <i>Martin Mihaljević</i>	674
Tritium <i>Austin Long</i>	639	Zirconium: Element and Geochemistry <i>François Farges</i>	675
Tungsten <i>John C. Groen</i>	639	Appendix A: List of entries by subject	676
Uranium: Element and Geochemistry <i>Fernando Bea</i>	645	Appendix B: Alphabetical list of the chemical elements (up to 103)	680
Uranium–Lead Thorium–Lead Decay System <i>P. Vidal</i>	648	Appendix C: The international system of units	682
Uranium Series Disequilibria <i>Michel Condomines</i>	650	Index of authors cited	685
		Subject index	703