

References

- Ampornmaha, A. 1995. Triassic carbonate rocks in the Phattalung area, Peninsular Thailand. *Journal of Southeast Asian Earth Science* 11: 225-236
- Arai, S. 1992. Chemistry of chromian spinel in volcanic rocks as a potential guide to magma chemistry. *Mineralogical Magazine* 56: 173-184.
- Arai, S. 1994a. Characterization of spinel peridotites by olivine-spinel compositional relationships: Review and interpretation. *Chemical Geology* 113: 191-204.
- Arai, S. 1994b. Compositional variation of olivine-chromian spinel in Mg-rich magma as a guide to their residual spinel peridotites. *Journal of Volcanology and Geothermal Research* 59: 279-293.
- Arai, S., and Hisada, K. 1991. Detrital chromian spinels from the Ishido Formation of the Sanchu Cretaceous Formations, Kanto Mountains, central Japan. *Journal of Mineralogy, Petrology and Economic Geology* 86: 540-553 (in Japanese with English abstract).
- Arai, S., and Matsukage, K. 1996. Petrology of the gabbro-troctolite-peridotite complex from Hess Deep, equatorial Pacific: implications for mantle-melt interaction within the oceanic lithosphere. In C. Mevel, K.M. Gillis, J.F. Allan, and P.S. Meyer (eds.), *Proceedings of the Ocean Drilling Program, Scientific Results* 147: 135-155.
- Arai, S., and Okada, H. 1991. Petrology of serpentine sandstone as a key to tectonic development of serpentine belts. *Tectonophysics* 195: 65-81.
- Arai, S., Kadoshime, K., Manjoorsa, M.V., David, C.P., and Kida, M. 1997. Chemistry of detrital chromian spinels as an insight into petrological characteristics of their source peridotites: an example from the Ilocos Norte ophiolite, northern Luzon, Philippines. *Journal of Mineralogy, Petrology and Exonomix Geology* 92: 137-141.
- Barr, S.M. and Macdonald, A.S., 1987. Nan River suture zone, northern Thailand, *Geology* 15, 907-910.
- Barr, S.M., and Macdonald, A.S. 1991. Toward a late Paleozoic-early Mesozoic tectonic model for Thailand. *Journal of Thai Geosciences* 1: 11-22.
- Basu, A., Young, S. W., Sutter, L.J., James, W. C., and Mack, G.H. 1975. Re-evaluation of the use of undulatory extinction and polycrystallinity in detrital quartz for provenance interpretation. *Journal of Sedimentary Petrology* 45: 873-882.

- Basu, A. R., and Molinaroli, E. 1991. Reliability and application of detrital opaque Fe-Ti oxide minerals in provenance determination. In A.C. Morton, S.P. Todd, and P.D.W. Haughton (eds.), *Developments in Sedimentary Provenance Studies*, Geological Society of London, Special Publication 57: 55-65.
- Baum F., and Koch, K.E. 1968. Ein Beitrag zur stratigraphischen Neuordnung des Paläozoikums in Süd-Thailand. *Geologisches Jahrbuch* 86: 879-884.
- Baum, F., Braun E.v., and Koch, K.E. 1979. *Geological map of northern Thailand 1:250,000: Sheet (Chiang Mai) 5*. Federal Institute for Geosciences and Natural Resources.
- Baum, F., Bruan, E. von, Hess, A., Koch, K.E., Kruse, G., Quarch, H., and Siebenhüner, M. 1970. On the Geology of northern Thailand. *Beihefte zum Geologischen Jahrbuch* 102, 23 p.
- Bernier, L.R. 1990. Vanadiferous zirconian-chromian hercynite in a metamorphosed basalt-hosted alteration zone, Atik Lake, Manitoba. *Canadian Mineralogist* 28: 37-50.
- Bloomer, S.H., and Hawkins, J.W. 1987. Petrology and geochemistry of boninite series volcanic rocks from the Mariana trench. *Contributions to Mineralogy and Petrology* 97: 361-377.
- Boriphathkosol, S. 1990. *Geological survey report of Amphoe Khun Yuam and Ban Mae La Luang sheet (1:50,000)*. Geological Survey Division, Department of Mineral Resources, Bangkok. (in Thai)
- Braun, E.v. 1969. *On the age of the granites in Northern Thailand*. Second Technical Conference on Tin, Bangkok.
- Braun, E. Von, and Jordan, R. 1976. The stratigraphy and paleontology of the Mesozoic sequence in the Mae Sot area in Western Thailand. *Geologisches Jahrbuch*. B 21. 5-51.
- Brown, G. F., Buravas, S., Charaljavanaphet, J., Jallichandra, N., Johnston, W. D., Sresthaputra, V., and Taylor, G.C. 1951. Geologic reconnaissance of the mineral deposits of Thailand. Geologic investigations in Asia. *Bull. Geol. Surv.* 984: 183 p.
- Buffetaut, E., and Suteethorn, V. 1993. The dinosaurs of Thailand. *Journal of Southeast Asian Earth Science*, 8(1-4). 77-82.
- Buffetaut, E., Raksaskulwong, L., Suteethorn, V., and Tong, H. 1994. First post-Triassic temnospondyl amphibians from the Shan-Thai block: intercentra from the Jurassic of Peninsular Thailand. *Geol. Mag.* 131(6). 837-839.

- Bunopas, S. 1976. Stratigraphic successions in Thailand-a preliminary summary. *Journal of the Geological Society of Thailand*, 2: 31-58.
- Bunopas, S. *Paleogeographic History of Western Thailand and Adjacent Parts of Southeast Asia-A Plate Tectonic Interpretation*. Doctoral dissertation. Victoria University of Wellington, New Zealand, 1981; reprinted 1982 as Geological Survey Paper 5 , Department of Mineral Resources, Thailand.
- Bunopas, S. 1992. Regional stratigraphic correlation in Thailand. In C. Piancharoen (ed.), *Proceedings of a National Conference of Geological Resources of Thailand: Potential for Future Development. Supplementary Volume*, pp. 189-208. November 1992, Bangkok, Thailand.
- Bunopas, S. 1994. Regional stratigraphy, paleogeographic and tectonic events of Thailand and continental Southeast Asia. In P. Angsuwathana and T. Wongwanich, W. Tansathien, S. Wongsomsak, and J. Tulyatid. (eds.), *Proceedings of the International Symposium on Stratigraphic Correlation of Southeast Asia*, pp. 2-24. 15-20 November 1994, Bangkok, Thailand: Department of Mineral Resources, Ministry of Industry.
- Bunopas, S., and Vella, P., 1983. Tectonic and geologic evolution of Thailand. In P. Nutalaya (ed.), *Proceedings of the Workshop on stratigraphic correlation of Thailand and Malaysia*, pp. 307-323. 8-10 September 1983. Haad Yai, Thailand.
- Bunopas, S., and Vella, P. 1992. Geotectonics and geology evolution of Thailand. In C. Piancharoen (ed.), *Proceedings of a National Conference of Geologic Resources of Thailand: Potential for Future Development*, Supplementary Volume, pp. 209-228. 17-24 November 1992, Bangkok. Thailand.
- Buravas, S. 1961. Stratigraphy of Thailand. Proc. Ninth Pacific Science Congress 1957. 12. 301-303.
- Burrett, C.F. 1974. Plate tectonic and the fusion of Asia. *Earth and Planetary Science Letters* 21: 181-189.
- Burrett, C., Long, J., and Stait, B. 1990. Early-Middle Paleozoic biogeography of Asia terranes derived from Gondwana. In W.S. McKerrow and C.R. Scotese (eds.), *Paleozoic Paleogeography and Biogeography Geol. Soc.* 12: 163-174.
- Caridroit, M., Bohlke, D., Lumjuan, A., Helmcke, D., and Wever, P.D. 1993. A mixed radiolarian fauna (Permian/Triassic) from clastics of the Mae Sariang area.

- northwestern Thailand. In T. Thanasuthipitak (ed.), *International Symposium on Biostratigraphy of Mainland Southeast Asia: Facies & Paleontology*, 401-413, 31 January - 5 February 1993. Chiang Mai.
- Chaodumrong, P. 1992. Report of Investigation on Geology Continuity of Eastern Region (1:250,000). Geological Survey Division, Department of Mineral, Resources Ministry of Industry, Bangkok. 39 p. (in Thai)
- Chaodumrong, P. 1994. Sedimentology and tectonic implication of Triassic submarine fans, Lampang Group, central north Thailand. In P., Angsuwathana, T. Wongwanich, W. Tansathien, S. Wongsomsak, and J. Tulyatid. (eds.), *Proceedings of the International Symposium on Stratigraphic Correlation of Southeast Asia*, pp. 208-225. 15-20 November 1994, Bangkok, Thailand: Department of Mineral Resources, Ministry of Industry.
- Chaodumrong, P., and Burrett, C. 1992. Revised stratigraphy of the Lampang Group and Provenance of volcanoclastic sandstones. *Paper presented at Technical Annual Meeting on Volcanic and volcanoclastic rocks of Thailand*, Geology Department, Chiang Mai University, 28 pp.
- Chaodumrong, P., and Burrett, C. 1997. Early late Triassic continental colliding between Shan-Thai and Indochina terranes as indicated by occurrence of fan delta red beds of Pha Daeng Formation, central north Thailand. In P. Dheeradilok, C. Hinthorn, P. Chaodumrong, P. Putthapiban, W. Tansathien, C. Utha-aroon, N. Sattayarak, T. Nuchanong, and S. Techawan (eds.), *Proceedings of the International Conference on Stratigraphy and Tectonic Evolution of Southeast Asia and the South Pacific*, Bangkok, 143-163. 19-24 August 1997, Bangkok, Thailand: Department of Mineral Resources, Ministry of Industry.
- Chaodumrong, P., and Rao, P. 1992. Depositional environments of Triassic carbonates, Lampang Group, central north Thailand. In C. Piencharoen, *Proceedings of a National Conference on Geological Resources of Thailand: Potential for Future Development*, pp. 355-367. 17-24 November 1992, Bangkok, Thailand: Department of Mineral Resources.
- Charoenprawat, A., Dhamdusadi, V., Paksamut, P., and Paksamut, N. 1985. *Geological map of Thailand 1:50,000, Sheet 4547 II Ban Huai Pong*. Department of Mineral Resources.

- Charusiri, P. 1989. Lithophile metallogenic epochs of Thailand: A geological and geochronological investigation. An unpublished Ph.D. Thesis Queen University, Kingston, Ontario, Canada. 819 pp.
- Charusiri, P., and Galong, V., 1995, SEDBA and related computer programmes in the geological studies of Ban Tha Si area, Lampang, northern Thailand. *Sedimentary Facies and Paleogeography*. 15, no. 2, 91-99.
- Charusiri, P., Kosuwan, S., and Imsamut, S. 1997. Tectonic evolution of Thailand: from Bunopas (1981)'s to a new scenario. In P. Dheeradilok and others (eds.), *Proceedings of the International Conference on Stratigraphy and Tectonic Evolution of Southeast Asia and the South Pacific*, pp. 414-420. 19-24 August 1997, Bangkok, Thailand.
- Charusiri, P., Hisada, K., Arai, S., Chutakosithanon, and Daorerk, V. 1999. Chromian spinel: an indicator mineral to tectonic setting of Thailand-a preliminary synthesis (abstract). In Khantaprab, C (ed.), *Mew2000 Proceedings Symposium on Mineral, Energy, and Water Resources of Thailand: Towards the Year 2000*, pp. 217-220. 28-29 October 1999, Bangkok, Thailand.
- Charusiri, P., Pongsapich, W., Vedchakarnchana, S., and Suwanwerakarntorn, R. 1992. *Studies on the relationships between fractures and mineralization in the Nam Moei nad Nam Mae Ping areas, Chanwat Chiang Mai, Mae Hong Son, and Tak*. 94 pp.
- Charusiri, P., Chonglakmani, C., Daorerk, V., Supanathi, S., and Imsamut, S. 1994. Detailed stratigraphy of the Ban Tha Si area, Lampang, northern Thailand: Implications for paleoenvironments and tectonic history. In P., Angsuwathana, T. Wongwanich, W. Tansathien, S. Wongsomsak, and J. Tulyatid. (eds.), *Proceedings of the International Symposium on Stratigraphic Correlation of SE Asia, IGCP Project 306*, pp. 306-321. 15-20 November 1994. Bangkok, Thailand.
- Chonglakmani, C. 1972. Stratigraphy of the Triassic Lampang Group in Northern Thailand. *Newsletter of the Geological Society of Thailand*. 5(5-6), 33-36.
- Chonglakmani, C. The systematics and biostratigraphy of Triassic bivalves and ammonoids of Thailand. Doctoral dissertation. Auckland University, New Zealand. 1981.
- Chonglakmani, C. 1983. The marine Mesozoic stratigraphy of Thailand, In P. Nutalaya (ed.), *Proceedings of the Workshop on stratigraphic correlation of Thailand and*

- Malaysia*, pp. 105-126. 8-10 September 1983. Haad Yai, Thailand.
- Chonglakmani, C. 1999. The Triassic system of Thailand; implication for the paleogeography of Southeast Asia. In B Rattanasthien (ed.), *International symposium shallow tethys (ST) 5*, pp. 486-495. 1-5 February, 1999. Chiang Mai, Thailand.
- Chonglakmani, C., and Sattayarak, N. 1978. Stratigraphy of the Huai Hin Lat Formation (Upper Triassic) in northeastern Thailand. In P. Nutalaya (ed.). *Proceedings of the Third regional conference on geology and mineral resources of southeast Asia*, pp. 739-762. 14-18 November, 1978, Bangkok, Thailand.
- Chonglakmani, C., Gabel, J., Helmcke, D., Lumjuan, A., and Meischner, D., 1991, Geodynamic interpretation of marine Triassic basins in northern Thailand. *Seventh regional conference on geology, mineral and energy resources of Southeast Asia*. Abstract, pp.13, Bangkok, Thailand.
- Chutakosikanon, V. Characteristics of detrital chromian spinels in sandstones from the Nam Duk Formation, Amphoe Lom Sak and Amphoe Nam Nao, Changwat Phetchabun. Master's Thesis, Department of Geology, Graduate School, Chulalongkorn University, 2000.
- Cookenboo, H.O., Bustin, R.M., and Wilks, K.R. 1997. Detrital chromian spinel compositions used to reconstruct the tectonic setting of provenance: implications for orogeny in the Canadian Cordillera. *Journal of Sedimentary Research* 67: 116-123.
- Department of Mineral Resources. 1999. *Geological map of Thailand 1:1,000,000*.
- Dheeradilok, P., Wongwanich, T., Tansathien, W. and Chaodumrong, P. 1992. An introduction to geology of Thailand. In C. Piancharoen (ed.), *Proceedings of a National Conference of Geologic Resources of Thailand: Potential for Future Development, Supplementary Volume*, pp. 737-752. 17-24 November 1992. Bangkok, Thailand.
- Dick, K.J.B. 1977. Partial melting in the Josephine Peridotite I, the effect on mineral composition and its consequence for geobarometry and geothermometry. *American Journal of Sciences* 277: 801-832.
- Dick, H.J.B., and Bullen, T. 1984. Chromian spinel as a petrogenetic indicator in abyssal and alpine-type peridotites and spatially associated lava. *Contributions to Mineralogy*

and *Petrology* 86: 54-76.

- Dickinson, W.R., and Suczek, C.A. 1979. Plate tectonics and sandstone compositions. *American Association of Petroleum Geologists Bulletin* 63: 2164-2182.
- Dickinson, W.R., Beard, L.S., Brakeridge, G.R., Erjavec, J.J., Ferguson, R.C., Inman, K.F., Knepp, R.A., Lindberg, F.A., and Ryberg, P.T. 1983. Provenance of North American Phanerozoic sandstones in relation to tectonic setting. *Geological Society of America Bulletin* 94: 222-235.
- Evans, B.W., and Frost, B.R. 1975. Chrome-spinel in progressive metamorphism—a preliminary analysis. *Geochim. Cosmochim. Acta.* 39: 959-972.
- Fisk, M.R., and Bence, A.E. 1980. Experimental crystallization of chrome spinel in FAMOUS basalt 527-1-1. *Earth and Planetary Science Letters* 48: 111-123.
- Folk, R.L. 1959. Practical petrographic classification of limestones. *American Association of Petroleum Geologists Bulletin* 43: 1-38.
- Folk, R.L. 1974. *Petrology of sedimentary rocks*. Austin, Texas. Hemphill: 182.
- Fontaine, H. et. al., 1988. Late Paleozoic and Mesozoic fossil of West Thailand and their environments, *CCOP Technical Bulletin* 20, p.62-63.
- Fontaine, H., and Salyapongse, S. 1997. Unexpected discovery of Early Carboniferous (Late Visean-Serpukhivian) corals in east Thailand. In P. Dheeradilok, C. Hingthong, P. Chaodumrong, P. Putthapiban, W. Tansathier, C. Utha-aroon, N. Sattayarik, T. Nuchanong, and S. Techawan (eds.), *Proceedings of the International conference on Stratigraphigraphy and Tectonic Evolution of Southeast Asia and the South Pacific*, pp. 48-52. 19-24 August 1997, Bangkok, Thailand.
- Fontaine, H., and Tantiwanit W. 1992. Permian and Triassic fossils from Phangnga. Peninsular Thailand. *CCOP Newsletter*. 17. 18-20.
- Fontaine, H., Chonglakmani, C., Piyasin, S., Ibrahim, B.A., and Khoo, H., P. 1993. Triassic limestones within and round the Gulf of Thailand. *Journal of Southeast Asian Earth Science*, 8. 83-95.
- Gatinsky, Y.G., Mischna, A.V., Vinogradov, I. V., and Kovalev, A. A. (1978) The main metallogenic belts of southeast Asia as the result of different geodynamic conditions interference. In P. Nutallaya (ed.), *Proceedings of the Third regional conference on geology and mineral resources of southeast Asia*, pp. 313-318. 14-18 November, 1978, Bangkok, Thailand.

- Glassley, W. 1974. Geochemistry and tectonics of the Crescent volcanic rocks, Olympic Peninsula, Washington. *Geological Society of American Bulletin* 85: 785-794.
- Grant-Mackie, J.A., Sawata, H., Arpornsuwan, S., Arrykul, S., Chutatis, V., and Punggrassami, T. 1980. Some Triassic and associated strata of southern Thailand. *Prince of Songkhla University Geological Research Project* 5, 85 p.
- Gregory, J.W. 1930. Upper Triassic fossils from the Burmo-Siamese Frontier. The Thaungyin Triassic and description of the corals. *Rec. geol. Surv. India* 63: 155-167.
- Hada, S. 1990. Geology of the Nan-Chanthaburi suture zone (I)-stratigraphy and geological structure (abstract). In P. Charusiri, V. Pisutha-Arnond, S. Jarupongsakul (eds.). *Proceedings of the Technica Conference on Development Geology For Thailand Year 2000*, Chulalongkorn University, Bangkok.
- Hada, S., Bunopas, S., Salyaphongse, S., Thitisawan, V., Panjasawatwong, Y., Yaowanoyothin, W., Ishi, K., and Yoshikura, S., 1991. Terrane analysis and tectonics of the Nan-Chantha Buri suture zone, Thailand (abstract). *GEOSEV VII*, Bangkok, 40p.
- Hagen, D., and Kemper, E. 1976. Geology of the Thong Pha Phum area (Kanchanaburi province, western Thailand). *Geologisches Jahrbuch*, B21: 53-91.
- Haggerty, S.E. 1976. Oxidation of opaque mineral oxides in basalts. In D. Rumble (ed.), *Oxide minerals, Reviews in Mineralogy* 3, Mineralogical Society of America., pp. Hg 1-Hg 100.
- Haggerty, S.E. 1991. Oxide mineralogy of the upper mantle. In D.H. Lindsley (ed.), *Oxide minerals: petrologic and magnetic significance, Reviews in Mineralogy* 25. 355-416.
- Hahn, L., and Siebenhüner, 1982. *Explanatory Notes (Paleontology) on the Geological Maps of Northern and Western Thailand 1:250,000 (Sheets Nan, Chiang Rai, Phayao, Chiang Dao, Chiang Mai, Li, Thong Pha Phum)*. Bundesanstalt für Geowissenschaften und Rohstoffe (Hannover), 76p.
- Hahn, L., Koch, K. E., and Wittekindt, H. 1986. Outline of the geology and the mineral potential of Thailand. *Geologisches Jahrbuch*, 59: 3-49.
- Hayami, I. 1960. Two Jurassic pelecypods from west Thailand . *Trans. Proc. Palaeont. Soc. Japan*. 38, 284 p.
- Hayami, I. 1972. Lower Jurassic Bivalvia from the environs of Saigon. *Geology and*

- Paleontology of Southeast Asia* 10, 179-230.
- Heim, A., and Hirschi, H. 1939. A section of the mountain ranges of North-Western Siam. *Ecl. Geol. Helv.* 32, 1:1-16.
- Helmcke, D. 1983. Variscan and Indosinian orogeny in central Southeast-Asia: a contradiction or a completion. In T. Thanasuthipitak (ed.), *Proceedings of the Annual Technical Meeting 1982, Special Publication No. 4 (1983)*, pp. 101-107. 1-2 February 1983, Chiang Mai, Thailand.
- Helmcke, D., 1985. The Permo-Triassic "Paleotethys" in mainland SE Asia and adjacent parts of China. *Geologische Rundschau* 74: 215-228.
- Helmcke, D., 1986, Die Alpen und die Kimmeriden: Die verdoppelte Geschichte der Tethys-Discussion; *Geologische Rundschau* 75: 495-499.
- Helmcke, D., and Kraikhong, C., 1982. On the geosynclinal and orogenic evolution of central and northeastern Thailand. *Journal of the Geological Society of Thailand*, 5: 52-74.
- Helmcke, D., and Lindenberg, H.G., 1983, New data on the "Indosinian" orogeny from central and northeastern Thailand. *Geologische Rundschau* 72: 317-328.
- Helmcke, D., Ingavat-Helmcke, R., and Meischner, D., (in prep.), Spät-variszische Orogenese und Terranes in SE-Asien; *Göttinger Arbeiten zur Geologie u. Paläontologie*.
- Helmold, K.P. 1985. Provenance of feldspathic sandstones-effect of diagenesis on provenance interpretations: a review. In G.G. Zuffa (ed.), *Provenance of Arenite*, pp. 139-163. Dordrecht, the Netherlands: Reidel.
- Hess, A., and Koch, K.E. 1979. *Geological map of northern Thailand 1:250,000: Sheet (Chiang Dao) 4*. Federal Institute for Geosciences and Natural Resources.
- Hisada, K., and Arai, S. 1993. Detrital chromian spinels in the Cretaceous Sanchu sandstone, Central Japan: indicator of serpentinite protrusion into a fore-arc region. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 105: 95-109.
- Hisada, K., and Arai, S. 1994. Serpentinite protruded into fore-arc region: implications of detrital chromian spinels in Cretaceous sandstones of the Kanto Mountains, Japan. In F. Kumon, and K.M. Yu (eds.), *Proceedings of 29th International Congress*. pp. 153-164. Utrecht: VSP.
- Hisada, K., Arai, S., and Yamaguchi, T. 1998. Detrital chromian spinels from Site 960 in the

- Cote d'Ivoire-Ghana Transform Margin. In J. Mascle, G.P. Lohmann, and M. Moullade (eds.), *Proceedings of the Ocean Drilling Program, Scientific Results* 159: pp. 133-139.
- Högbom, B. 1914. Contributions to the geology and morphology of Siam. *Bull. Geol. Instit. Univ. Upsala*, XII: 65-128.
- Hutchison C.S. 1989. Geological evolution of southeast Asian. *Oxford Monography on Geology and Geophysics*, 13. 368 p.
- Igo, H., Nagano, N., and Nakinbodee, V. 1988. Middle Triassic conodonts from southern Thailand. *Annul Report of Institute Geoscience the University Tsukuba* 14: 46-5.
- Ingavat, R., 1984, On the correlation of the Permian foraminiferal faunas of the western, central and eastern provinces of Thailand. *Mémoires de la Société Géologique de France*, 147: 93-100.
- Ingavat, R., Toriyama, R., and Pitakpaivan, K., 1980, Fusuline zonation and faunal characteristics of the Ratburi Limestone in Thailand and its equivalents in Malaysia; *Geology and Paleontology of Southeast Asia*, 21: 43-56.
- Irvine, T.N. 1965. Chromian spinel as a petrogenetic indicator: Part 1 Theory. *Canadian Journal of Earth Sciences*, 2: 648-672.
- Irvine, T.N. 1967. Chromian spinel as a petrogenetic indicator: Part 2 Petrologic applications. *Canadian Journal of Earth Sciences*, 4: 71-103.
- Irvine, T.N. 1977. Origin of chromitite layers in the Muskox intrusion and other stratiform intrusions: a new interpretation. *Geology*, 5: 273-277.
- Iwai, J., Asama, K., Veeraburus, M., and Hongnusunthi, A., 1966. Stratigraphy of the so-called Khorat Series and a note on the fossil plant-bearing Palaeozoic strata in Thailand: *Geology and Paleontology of Southeast Asia*, Tokyo University Press 2. 179-196.
- Jalichan, N., and Bunnag, D. 1954. *A report on geologic reconnaissance of the mineral resources of northeastern Thailand*: manuscript in Thai with English translation in the file of the Geological Survey of Thailand, Dept. of Min. Resources, Bangkok.
- Javanaphet, J., C., and Sethaput, V. 1969. *Geological Map of Thailand, Scale 1:1,000,000*. Bangkok.
- Jindasuth, S., Krisadasima, Su., Tantiweanit, W., and Vacher, M., 1990. *Geological survey report of Amphoe Mae La Noi and Ban Kong Sum sheet (1:50,000)*. Geological

- Survey Division, Department of Mineral Resources, Bangkok. (in Thai)
- Kamata, Y., Sashida, K., Ueno, K., Hisada, K., Nakornsri, N., and Charusiri, P. 2002. Triassic radiolarian faunas from the Mae Sariang area, northern Thailand and their paleogeographic significance. *Journal of Asian Earth Sciences*, 20. 491-506
- Kemper, E., 1976. The foraminifera in the Jurassic limestone of west Thailand. *Geologisches Jahrbuch*, B21: 129-153.
- Kemper, E., Maronde, H. D., and Stoppel, D. 1976. Triassic and Jurassic limestone in the region northwest and west Si Sawat (Kanchaanaburi Province, western Thailand). *Geologisches Jahrbuch*, B21: 93-127.
- Kiriwat, V., and Suensilpong, S. 1964. *Geology map of Ban Tha Si (47Q/DC 12), Scale 1:50,000*. Geological Survey Division, Department of Mineral Resources, Bangkok, Thailand (unpublished).
- Kobayashi, T., and Igo, H. 1966. On the occurrence of graptolites in north Thailand. *Geology and Paleontology of Southeast Asia 2*: 1-8.
- Kobayashi, T., and Tokuyama, A. 1959. The Halobiidae from Thailand. *J. Fac. Sci. Uni. Tokyo*, Sect. II, Geol., Mkiner., Geogr., Geohpys., 12, 1: 27—30.
- Koch, K.E. 1973. Geology of the region Sri Sawat-Thong Pha Phum-Sangkhlaburi (Kanchanaburi Province/Thailand). *Bulletin Geological Society of Malaysia*, 6: 177-185.
- Konishi, K., 1953. New Boultonia and other microfossils from north Thailand. *Trans. Proc. Palaeont. Soc. Japan*. 12: 103-110.
- Kummel, B. 1960. Triassic Ammonoids from Thailand. *J. Paleont.* 34: 382-694.
- Klein, C., and Hurlbut, C.S., Jr. 1993. *Manual of mineralogy*. 21st (ed.). New York: John Wiley&Sons.
- LaMoreaux, P.E., Javanaphet, J.C., Chaleechan, N., Na Chiangmai, P., Bunnag, D., thavisri, A., and Rakprathum, C. 1959. Reconnaissaance of the geology and groundwater of the Khorat Plateau, Thailand. *United States Geological Survey Water-Supply Paper*, 1429: 407-415.
- Lee, W.M. 1923. *Reconnaissance geological report of the districts of Payap and Maharashtra, Northern Siam* Department of State Railways, Bangkok. 16 p.
- Lewis, D.W. 1982. Channels across continental shelves: corequisites of canyon-fan

- systems and potential petroleum conduits. *New Zealand Journal of Geology and Geophysics* 23: 353-369.
- Liengsakul, M. 1979. *Origin, classification and correlation of sedimentary rocks of Lampang Group (Triassic) in Lampang Province*. Master's Thesis, Chiang Mai University, Chiang Mai.
- Meesook, A. 1994. *Marine Jurassic stratigraphy and bivalve paleontology of Thailand*. Doctoral dissertation, University Auckland.
- Meesook, A., and Grant-Mackie, J.A., 1996. Marine Jurassic lithostratigraphy of Thailand, *Journal of Southeast Asian Earth Sciences*, 14: 337-391.
- Meesook, A., and Grant-Mackie, J. A. (in prep)-- Systematic paleontology of Marine Jurassic bivalves of Thailand.
- Meesook, A., and Grant-Mackie, J. A. 1994. Biostratigraphic correlation of marine Jurassic rocks within Thailand and Southeast Asia. In P., Angsuwathana, T. Wongwanich, W. Tansathien, S. Wongsomsak, and J. Tulyatid. (eds.), *Proceedings of the International Symposium on Stratigraphic Correlation of Southeast Asia*, pp. 160-169. 15-20 November 1994, Bangkok, Thailand: Department of Mineral Resources, Ministry of Industry.
- Meesook, A., Chitmanee, S., and Sareerat, S. 1985. Geology of the Ban Chi Cho Chi Quadrangle (Sheet 4740-IV), scale 1:50,000. *Geol. Surv. Report 1*. Geological Survey Division, Department of Mineral Resources, Bangkok. 40 p. (in Thai)
- Meesook, A., Sareerat, S., and Chitmanee, S. 1985. Geology of the Ban Pa La Tha Quadrangle (4740-I) scale 1:50,000, Amphoe Umphang, Changwat Tak, western Thailand. *Strat. Correl. Res. Unit Rep.* 3. Geological Survey Division, Department of Mineral Resources, Bangkok. 40 p. (in Thai)
- Meesook, A., Sareerat, S., Suteethorn, V., and Chitmanee, S. 1985. Geology of the Ban Klo Tho Quadrangle (4741-III), Scale 1:50,000, Amphoe Umphang, Changwat Tak, western Thailand. *Strat. Correl. Res. Unit Rep.* 2, Geological Survey Division, Department of Mineral Resources, Bangkok. 35 p. (in Thai)
- Meesook, A., Suteethorn, V., Sareerat, S., and Chitmanee, S. 1985. Geology of the Amphoe Umphang Quadrangle (4741-II), scale 1:50,000, Amphoe Umphang, Changwat Tak, western Thailand. *Strat. Correl. Res. Unit Rep.* 1. Geological Survey Division, Department of Mineral Resources, Bangkok. 36 p. (in Thai).

- Meesook, A., Suttethorn, V., Chaodumrong, P., Wongprayun, T., Teerarungsigul, N., Saarsud, A. 2000. Mesozoic Era. *Conference on Geology and Mineral Deposits in Thailand*. 47-58.
- Metcalf, I. 1988. Origin and assembly of south-east Asian continental terranes. In M., G. Audle-Charles, and A. Hallam (eds.), *Gondwana and Tethys*: 101-118
- Metcalf, I. 1996. Pre-Cretaceous evolution of SE Asian terranes. In R. Hall and D. Blundell (eds.), *Tectonic Evolution of Southeast Asia*: 97-122.
- Metcalf, I. 1997. The Paleo-Tethys and Paleozoic-Mesozoic tectonic evolution of Southeast Asia. In P. Dheeradilok and others (eds.), *Proceedings of the International Conference on Stratigraphy and Tectonic Evolution of Southeast Asia and the South Pacific*, pp. 260-272. 19-24 August 1997. Bangkok, Thailand: Department of Mineral Resources, Ministry of Industry.
- Mitchell, A. H. G. (1981) Phanerozoic plate boundaries in mainland SE Asia, the Himalayas, and Tibet. *Journal of the Geological Society London* 138: 109-122.
- Mouret, C. 1994. Geology studies of detrital heavy minerals and their application to provenance research. In A.C. Morton, S.P. Todd, and P.D.W. Haughton (eds.), *Developments in Sedimentary Provenance Studies, Geological Society of London, Special Publication 57*: 31-45.
- Mutti, E., and Ricci-Lucci, F. 1978. Turbidites of the northern Apennines: introduction to facies analysis. *International Geology Review* 20: 125-166.
- Panjasawatwong, Y. 1991. *Petrology, geochemistry and tectonic implications of the igneous rocks in the Nan Suture, Thailand, and an empirical study of the effect of Ca/Na, Al/Si and H₂O on plagioclase-melt equilibria at 5-10 kb pressure*. Doctoral dissertation. University Tasmania.
- Pettijohn, F. J. 1975. *Sedimentary Rocks*. 3rd edition. New York: Harper and Row: 628.
- Phonprasit, C., and Prasomsub, T. 1984. Geology of Changwat Chonburi and Rayong. Department of Mineral Resources. 40 p. (in Thai)
- Pia, J. 1930. Upper Triassic fossils from the Burmo-Siamese frontier. A new Dasycladacea, *Holosporella siamensis* nov. gen., nov. spec., with a Description of the Allied Genus *Aciculella* Pia. *Rec. geol. Surv. India* 63: 177-181.
- Pitakpaivan, K. 1955. Occurrences of Triassic formation at Mae Moh. *Rep. Departm. Mines, Rep. Invest* 1: 47-45.

- Pitakpaivan, K. 1965. *The fusulinacean fossils of Thailand, Part I: Fusulines of the Rat Buri Limestone of Thailand*. Memoirs Faculty of Science, Kyushu University, Japan.
- Pitakpaivan, K., Ingavat, R., and Paritwatvorn, P. 1969. Fossils of Thailand. Geological Survey, Memorial 3, vol. I-III, Royal Department of Mineral Resources, Bangkok.
- Piyasin, S. 1971. Marine Triassic sediments of Northern Thailand. *Newsletter of the Geological Society of Thailand* 4: 12-20.
- Piyasin, S. 1971. *Geological map of Thailand, Changwat Lampang, 1:250,000*. Department of Mineral Resources.
- Piyasin, S. 1972. Geology of Changwat Lampang sheet: scale 1:250,000. Department of Mineral Resources. *Report of Investigation* 14.
- Piyasin, S. 1975. *Geology of Utraradit Sheet NE 47-11, scale 1:250,000*, Department of Mineral Resources. *Report of Investigation* 16. Department of Mineral Resources, 68 p. (in Thai with English summary).
- Pober, E., and Faupl, P. 1988. The chemistry of detrital chromian spinels and its implications for the geodynamic evolution of the Eastern Alps. *Geologische Rundschau* 77: 641-670.
- Polachan, S., and Sattayarak, N. 1989. Strike-slip tectonics and the development of Tertiary Basins in Thailand. In T. Thanasuthipitak, and P. Ounchanum (eds.), *Proceedings of the International Symposium on Intermontane Basins: Geology and Resources*, pp. 243-253. 30 January – 2 February 1989. Chiang Mai.
- Press, S. 1986. Detrital spinels from alpinotype source rocks in the Middle Devonian sediments of the Rhinish Massif. *Geologische Rundschau* 75: 333-340.
- Raksaskulwong, L. 1989. *Geologic map of Amphoe Khao Pra Nom and Ban Bang Pa, Scale 1:50,000*. Geological Survey Division, Department of Mineral Resources.
- Reed, S.J.B. 1996. *Electron microprobe analysis and scanning electron microscopy in geology*. Great Britain: Cambridge University Press.
- Ridd, M.F. 1980. Possible Paleozoic drift of Southeast Asia and Triassic collision with China. *Journal of the Geological Society London* 137, 635-64.
- Ridd, M. F., and Wainwright, A., C., J. 1969. Reconnaissance geology of Thailand. BP Petroleum Ltd., Bangkok.
- Ross, G.M., and Parrish, R.R. 1991. Detrital zircon geochronology of metasedimentary rocks in the southern Omineca belt, Canadian Cordillera. *Canadian Journal of Earth*

- Sciences* 28: 1254-1270.
- Sack, R.O., and Ghiorso, M.S. 1991. Chromite as a petrogenetic indicator. Oxide minerals: petrologic and magnetic significance. In D.H. Lindsley (ed.), *Reviews in Mineralogy* 25: 323-353.
- Sarapirome S. and Khundee S., 1994. *Preliminary Study on Neotectonics in the Mae Hong Son-Kkun Yuam Valley*. Geological Survey Division, Department of Mineral Resources Ministry of Industry, Bangkok.
- Sardsud, A. 1997. Discovery of Triassic carbonate rocks in Peninsular Thailand. *Mineral Resources Development Division Report, No. 9/1997*, Department of Mineral Resources. 38 p.
- Sashida, K. and Igo, H. 1992. Triassic radiolarian from a limestone exposed at Khao Chiak near Phatthalung, southern Thailand. *Trans. Proc. Palaeontol. Soc. Jap. New Ser.* 168, 1296-1310.
- Selly, R. 1996. *Ancient Sedimentary Environments and their sub-surface diagnosis*. 4th edition: 300.
- Shanmugam, G., and Moiola, R.J. 1988. Submarine fans: Characteristics, Models, Classification, and Reservoir Potential. *Earth-Science Reviews*, 383-428 Amsterdam.
- Sivabaworn, V., 1976. *Geological survey report of Chanthaburi Sheet (1:250,000)*. Geological Survey Division, Department of Mineral Resources, Bangkok. (in Thai)
- Smith, M.T., and Gehrels, G.E. 1991. Detrital zircon geochronology of Upper Proterozoic to Lower Paleozoic tectonic development of the eastern Canadian Cordillera. *Canadian Journal of Earth Sciences* 28: 1271-1284.
- Stauffer, P. H. 1974 Mala and south-east Asia in the pattern of continental drift. *Bulletin Geological Society of Malaysia* 7: 79-88.
- Stoppel, D. 1966-1969. *Unpublished paleontological reports*. Bundesanstalt für Bodenforschung, Hannover.
- Sugiyama, M. Collisional event between Sibumasu and Indochina based on detrital chromian spinels. Master's Thesis, Institute of Geoscience, University of Tsukuba, Japan, 2000.
- Sunyapong, S., 1992. *Graywacke of Eastern Region*. Geological Survey Division, Department of Mineral Resources, Bangkok. (in Thai).

- Tantiwanit, W., Raksaskulwong, L., and Chitmanee, S. 1985. *Geological map of Amphoe Mae Sot Quadrangle (Sheet 4742-III), scale 1:50,000*. Geological Survey Division, Department of Mineral, Resources Ministry of Industry, Bangkok.
- Thayer, T.P. 1970. Chromite segregations as petrogenetic indicators. *Geological Society South Africa Special Publish 1*: 380-390.
- Thy, P. 1983. Spinel minerals in transitional and alkali basaltic glasses from Iceland. *Contributions to Mineralogy and Petrology* 83(1983): 141-149.
- Teggin, D.E., 1975. *The granite of northern Thailand*. Doctoral dissertation. University Manchester.
- Foriyama, R. 1944. On some fusulinids from northern Thai. *Jap. J. Geol. and Geogr.* 19: 243-248.
- Toriyama, R., Pitakpaivan, K., and Ingavat, R., 1978, The paleogeographic characteristics of fusuline faunas of the Ratburi Group in Thailand and its equivalents in Malaysia; in P. Nutalaya (ed.), *Proceedings of the Thired regional conference on geology and mineral resources of southeast Asia*, pp. 107-111. 14-18 November, 1978, Bangkok, Thailand.
- Tofke, T., Lumjuan, A., and Kelmcke, D., 1993, Triassic syn-orogenic siliciclastics from the area of Mae Sariang (northwestern Thailand). In T. Thanasuthipitak (ed.), *International Symposium on Biostratigraphy of Mainland Southeast Asia: Facies & Paleontology*, pp. 391-400, 31 January - 5 February 1993, Chiang Mai.
- Tooriyama, R., 1994. Summary of the fusulinite faunas in Thailand and Malaysian. *Geology and Paleontology of Southeast Asia* 25: 137-146.
- Trauth, F. 1930. Upper Triassic fossils from the Burmo-Siamese frontier. On some fossils from the Kamawkale Limestone. *Rec. geol. Surv. India*, 63, 1: 174-176; Calcutta.
- Tulyatid, J., and Charusiri, P., 1999. The ancient Tethys in Thailand as indicated by nationwide airborne geophysical data: in Ratanasathin, B. and Rirb, SS.L. (eds.), *International Symposium on Shallow Tethys (ST5)*, 1-5 February, 1999, Chiang Mai University, Chiang Mai, Thailand, p.335-352.
- Ward, D.E., and Bunnag, D. 1964. Stratigraphy of the Mesozoic Khorat Group in Northeastern Thailand. *Rep. of Invest.* 6: 95 p. Geological Survey Division, Department of Mineral, Resources Ministry of Industry, Bangkok.
- Weir, J. 1930. Upper Trisassic fossils from the Burmo-Siamese Frontier. Brachiopoda and

- Lamellibranchia from the Thaungyin river. *Rec. geol. Surv. India* 63, 1: 168-173.
- Wilson, M. 1989. *Igneous Petrogenesis*. London: Unwin Hyman.
- Wolfart, R. 1969. *Unpublished paleontological reports*. Bundesanstalt für Bodenforschung, Hannover.
- Workman, D.R. 1975. Tectonic evolution of Indochina. *Journal of the Geological Society of Thailand* 1: 3-19.
- Wu, G., 1993. Late Paleozoic tectonic framework and Paleotethyan evolution in western Yunnan. *Scientia Geologica Sinica*, 2, 129-149.

APPENDIX

APPENDIX

Sugiyama's data of detrital chromian spinels in sandstone of the

Mae Sariang Group, Mae Hong Son

Sample No.	MSR4-1-6-1	MSR4-1-6-3	MSR4-1-6-4	MSR4-1-7-1	MSR4-1-7-2	MSR4-1-7-5	MSR4-1-8-2	MSR4-1-9-2	MSR4-2-2-1
SiO ₂	0.000	0.137	0.028	0.019	0.000	0.006	0.047	0.000	0.012
Al ₂ O ₃	20.378	16.354	27.541	25.637	32.567	20.921	28.227	34.741	24.861
TiO ₂	0.117	3.484	0.008	0.541	0.023	0.276	0.012	0.013	0.187
Cr ₂ O ₃	49.580	32.563	39.829	37.649	37.039	43.137	39.287	32.925	44.936
FeO	16.722	33.023	20.078	21.748	12.856	25.676	19.310	15.417	13.587
NiO	0.110	0.239	0.069	0.145	0.163	0.069	0.085	0.122	0.073
MnO	0.323	0.275	0.315	0.721	0.259	0.405	0.373	0.250	0.192
MgO	13.227	11.301	11.626	12.725	16.564	6.643	11.881	15.350	14.810
CaO	0.068	0.015	0.028	0.072	0.003	0.100	0.000	0.024	0.018
Na ₂ O	0.000	0.000	0.045	0.000	0.008	0.049	0.026	0.000	0.035
K ₂ O	0.000	0.051	0.012	0.011	0.003	0.037	0.015	0.018	0.032
Total	100.525	97.442	99.579	99.268	99.485	97.319	99.263	98.860	98.743
cation O									
SiO ₂	0.000	0.005	0.001	0.001	0.000	0.000	0.002	0.000	0.000
Al ₂ O ₃	0.600	0.481	0.810	0.754	0.958	0.616	0.831	1.022	0.731
TiO ₂	0.003	0.087	0.000	0.014	0.001	0.007	0.000	0.000	0.005
Cr ₂ O ₃	0.979	0.643	0.786	0.743	0.731	0.851	0.775	0.650	0.887
FeO	0.233	0.460	0.279	0.303	0.179	0.357	0.269	0.215	0.189
NiO	0.001	0.003	0.001	0.002	0.002	0.001	0.001	0.002	0.001
MnO	0.005	0.004	0.004	0.010	0.004	0.006	0.005	0.004	0.003
MgO	0.328	0.280	0.288	0.316	0.411	0.165	0.295	0.381	0.367
CaO	0.001	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.000
Na ₂ O	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001
K ₂ O	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	2.149	1.964	2.172	2.143	2.286	2.006	2.178	2.274	2.185
cation O=4									
Si	0.000	0.005	0.001	0.001	0.000	0.000	0.001	0.000	0.000
Al	0.744	0.654	0.995	0.938	1.118	0.818	1.017	1.199	0.893
Ti	0.003	0.089	0.000	0.013	0.001	0.007	0.000	0.000	0.004
Cr	1.214	0.873	0.965	0.924	0.853	1.132	0.949	0.762	1.082
Fe	0.433	0.936	0.515	0.565	0.313	0.713	0.494	0.378	0.346
Ni	0.003	0.007	0.002	0.004	0.004	0.002	0.002	0.003	0.002
Mn	0.008	0.008	0.008	0.019	0.006	0.011	0.010	0.006	0.005
Mg	0.611	0.571	0.531	0.589	0.719	0.329	0.541	0.670	0.673
Ca	0.002	0.001	0.001	0.002	0.000	0.004	0.000	0.001	0.001
Na	0.000	0.000	0.003	0.000	0.000	0.003	0.002	0.000	0.002
K	0.000	0.002	0.000	0.000	0.000	0.002	0.001	0.001	0.001
Total	3.018	3.144	3.021	3.056	3.014	3.020	3.016	3.019	3.009
Fe ²⁺	0.436	0.766	0.522	0.559	0.319	0.710	0.503	0.383	0.343
Fe ²⁺	0.391	0.384	0.473	0.414	0.284	0.668	0.462	0.335	0.324
Fe ³⁺	0.045	0.383	0.049	0.144	0.035	0.043	0.041	0.048	0.018
Mg#(Mg/(Mg+Fe ²⁺))	0.610	0.598	0.529	0.587	0.717	0.330	0.539	0.667	0.675
Cr#(Cr/(Al+Cr))	0.620	0.572	0.492	0.496	0.433	0.580	0.483	0.389	0.548
Fe ³⁺ 3#(Fe ³⁺ /Cr+Al+Fe ³⁺)	0.023	0.201	0.024	0.072	0.017	0.021	0.020	0.024	0.009
Al3#(Al/Cr+Al+Fe ³⁺)	0.371	0.342	0.495	0.468	0.557	0.411	0.507	0.597	0.448
Cr3#(Cr/(Cr+Al+Fe ³⁺))	0.606	0.457	0.480	0.461	0.425	0.568	0.473	0.379	0.543
Cr#(Cr/(Al+Cr))	0.620	0.572	0.492	0.496	0.433	0.580	0.483	0.389	0.548
TiO ₂ wt%	0.117	3.484	0.008	0.541	0.023	0.276	0.012	0.013	0.187

Sample No.	MSR4-2-2-2	MSR4-2-2-3	MSR4-2-3-4	MSR4-2-3-6	MSR4-2-3-7	MSR4-2-3-8	MSR4-2-4-2	MSR4-2-4-3	MSR4-2-6-1
SiO ₂	0.034	0.118	0.111	0.125	0.097	0.041	0.089	0.059	0.071
Al ₂ O ₃	29.430	12.094	10.635	12.903	14.036	27.151	27.558	35.971	13.125
TiO ₂	0.262	0.178	2.096	2.352	1.524	0.128	0.058	0.196	1.644
Cr ₂ O ₃	36.902	51.977	44.745	40.601	47.654	40.733	39.599	28.654	46.632
FeO	18.311	21.974	30.798	31.819	22.750	14.896	18.379	16.367	22.949
NiO	0.183	0.000	0.136	0.175	0.255	0.078	0.043	0.107	0.218
MnO	0.318	0.280	0.279	0.232	0.201	0.219	0.251	0.183	0.198
MgO	13.465	10.961	9.710	9.511	13.096	13.626	11.889	16.098	12.329
CaO	0.000	0.000	0.030	0.019	0.005	0.014	0.035	0.019	0.006
Na ₂ O	0.000	0.000	0.000	0.005	0.000	0.134	0.009	0.036	0.015
K ₂ O	0.000	0.034	0.005	0.004	0.002	0.055	0.022	0.016	0.000
Total	98.905	97.616	98.545	97.746	99.620	97.075	97.932	97.706	97.187
cation O									
SiO ₂	0.001	0.004	0.004	0.004	0.003	0.001	0.003	0.002	0.002
Al ₂ O ₃	0.866	0.356	0.313	0.380	0.413	0.799	0.811	1.058	0.386
TiO ₂	0.007	0.004	0.052	0.059	0.038	0.003	0.001	0.005	0.041
Cr ₂ O ₃	0.728	1.026	0.883	0.801	0.941	0.804	0.782	0.566	0.920
FeO	0.255	0.306	0.429	0.443	0.317	0.207	0.256	0.228	0.319
NiO	0.002	0.000	0.002	0.002	0.003	0.001	0.001	0.001	0.003
MnO	0.004	0.004	0.004	0.003	0.003	0.003	0.004	0.003	0.003
MgO	0.334	0.272	0.241	0.236	0.325	0.338	0.295	0.399	0.306
CaO	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000
Na ₂ O	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000
K ₂ O	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Total	2.198	1.972	1.928	1.929	2.043	2.160	2.153	2.263	1.981
cation O=4									
Si	0.001	0.004	0.004	0.004	0.003	0.001	0.003	0.002	0.002
Al	1.051	0.481	0.433	0.525	0.539	0.986	1.004	1.247	0.520
Ti	0.006	0.005	0.054	0.061	0.037	0.003	0.001	0.004	0.042
Cr	0.884	1.387	1.221	1.108	1.228	0.993	0.968	0.666	1.239
Fe	0.464	0.620	0.889	0.918	0.620	0.384	0.475	0.403	0.645
Ni	0.004	0.000	0.004	0.005	0.007	0.002	0.001	0.003	0.006
Mn	0.008	0.008	0.008	0.007	0.006	0.006	0.007	0.005	0.006
Mg	0.608	0.552	0.500	0.489	0.636	0.626	0.548	0.706	0.617
Ca	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.001	0.000
Na	0.000	0.000	0.000	0.000	0.000	0.008	0.001	0.002	0.001
K	0.000	0.001	0.000	0.000	0.000	0.002	0.001	0.001	0.000
Total	3.026	3.058	3.115	3.119	3.076	3.011	3.010	3.038	3.077
Fe ⁺	0.460	0.619	0.789	0.803	0.551	0.384	0.479	0.399	0.567
Fe ²⁺	0.393	0.462	0.481	0.486	0.348	0.370	0.452	0.300	0.364
Fe ³⁺	0.067	0.158	0.307	0.317	0.202	0.014	0.027	0.098	0.204
Mg#(Mg/(Mg+Fe ²⁺))	0.607	0.544	0.510	0.502	0.646	0.628	0.548	0.702	0.629
Cr#(Cr/(Al+Cr))	0.457	0.742	0.738	0.679	0.695	0.502	0.491	0.348	0.704
Fe ³⁺ 3#(Fe ³⁺ /Cr+Al+Fe ³⁺)	0.034	0.078	0.157	0.163	0.103	0.007	0.014	0.049	0.104
Al3#(Al/Cr+Al+Fe ³⁺)	0.525	0.237	0.221	0.269	0.274	0.495	0.502	0.620	0.265
Cr3#(Cr/(Cr+Al+Fe ³⁺))	0.442	0.685	0.623	0.568	0.623	0.498	0.484	0.331	0.631
Cr#(Cr/(Al+Cr))	0.457	0.742	0.738	0.679	0.695	0.502	0.491	0.348	0.704
TiO ₂ wt%	0.262	0.178	2.096	2.352	1.524	0.128	0.058	0.196	1.644

Sample No.	MSR4-2-7-1	MSR4-2-7-5	MSR4-2-11-1	MSR4-2-12-1	MSR4-2-12-2	MSR4-2-12-3	MSR4-2-13-1	MSR4-2-15-1	MSR4-2-15-2
SiO ₂	0.074	0.034	0.064	0.118	0.172	0.071	0.020	0.016	0.074
Al ₂ O ₃	33.281	14.951	26.436	18.153	12.022	31.726	24.717	23.098	20.872
TiO ₂	0.033	4.229	0.065	0.250	0.241	0.477	0.073	1.287	1.457
Cr ₂ O ₃	34.660	30.813	40.932	48.530	56.469	33.095	43.047	39.110	36.021
FeO	13.018	35.710	22.456	18.038	16.446	16.182	17.000	23.455	24.967
NiO	0.130	0.269	0.000	0.198	0.100	0.060	0.073	0.158	0.188
MnO	0.236	0.265	0.400	0.248	0.241	0.176	0.231	0.990	0.217
MgO	16.086	11.673	8.800	13.088	12.868	16.235	12.907	11.029	12.985
CaO	0.021	0.005	0.145	0.004	0.188	0.005	0.007	0.000	0.034
Na ₂ O	0.004	0.000	0.005	0.023	0.000	0.000	0.000	0.000	0.028
K ₂ O	0.006	0.029	0.015	0.007	0.014	0.019	0.021	0.000	0.064
Total	97.549	97.978	99.318	98.657	98.761	98.046	98.096	99.143	96.907

cation O									
SiO ₂	0.002	0.001	0.002	0.004	0.006	0.002	0.001	0.001	0.002
Al ₂ O ₃	0.979	0.440	0.778	0.534	0.354	0.933	0.727	0.680	0.614
TiO ₂	0.001	0.106	0.002	0.006	0.006	0.012	0.002	0.032	0.036
Cr ₂ O ₃	0.684	0.608	0.808	0.958	1.115	0.653	0.850	0.772	0.711
FeO	0.181	0.497	0.313	0.251	0.229	0.225	0.237	0.326	0.347
NiO	0.002	0.004	0.000	0.003	0.001	0.001	0.001	0.002	0.003
MnO	0.003	0.004	0.006	0.003	0.003	0.002	0.003	0.014	0.003
MgO	0.399	0.290	0.218	0.325	0.319	0.403	0.320	0.274	0.322
CaO	0.000	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.001
Na ₂ O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K ₂ O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Total	2.252	1.949	2.129	2.085	2.036	2.233	2.141	2.100	2.041

cation O=4									
Si	0.002	0.001	0.002	0.004	0.006	0.002	0.001	0.001	0.002
Al	1.159	0.602	0.974	0.683	0.463	1.115	0.906	0.863	0.802
Ti	0.001	0.109	0.002	0.006	0.006	0.011	0.002	0.031	0.036
Cr	0.810	0.832	1.012	1.225	1.459	0.780	1.058	0.980	0.929
Fe	0.322	1.020	0.587	0.482	0.450	0.404	0.442	0.622	0.681
Ni	0.003	0.007	0.000	0.005	0.003	0.001	0.002	0.004	0.005
Mn	0.006	0.008	0.011	0.007	0.007	0.004	0.006	0.027	0.006
Mg	0.709	0.594	0.410	0.623	0.627	0.722	0.598	0.521	0.631
Ca	0.001	0.000	0.005	0.000	0.007	0.000	0.000	0.000	0.001
Na	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.002
K	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.003
Total	3.013	3.174	3.004	3.037	3.027	3.040	3.016	3.047	3.098

Fe ⁺	0.326	0.810	0.595	0.476	0.444	0.387	0.445	0.587	0.616
Fe ²⁺	0.293	0.352	0.587	0.380	0.371	0.280	0.404	0.463	0.361
Fe ³⁺	0.034	0.458	0.008	0.097	0.073	0.107	0.041	0.124	0.254
Mg#(Mg/(Mg+Fe ²⁺))	0.708	0.628	0.411	0.621	0.628	0.721	0.597	0.530	0.636
Cr#(Cr/(Al+Cr))	0.411	0.580	0.509	0.642	0.759	0.412	0.539	0.532	0.537
Fe ³⁺ 3#(Fe ³⁺ /Cr+Al+Fe ³⁺)	0.017	0.242	0.004	0.048	0.037	0.053	0.020	0.063	0.128
Al ₃ #(Al/Cr+Al+Fe ³⁺)	0.579	0.318	0.489	0.341	0.232	0.557	0.452	0.439	0.404
Cr ₃ #(Cr/(Cr+Al+Fe ³⁺))	0.404	0.440	0.507	0.611	0.731	0.390	0.528	0.498	0.468
Cr#(Cr/(Al+Cr))	0.411	0.580	0.509	0.642	0.759	0.412	0.539	0.532	0.537
TiO ₂ wt%	0.033	4.229	0.065	0.250	0.241	0.477	0.073	1.287	1.457



Sample No.	MSR4-2-17-1	MSR4-2-17-2	MSR4-2-17-3	MSR4-2-17-4	MSR4-2-17-5	MSR4-2-18-1	MSR4-18-2	MSR4-2-18-3	MSR4-2-17-4
SiO2	0.036	0.069	0.024	0.046	0.021	0.061	0.009	0.132	0.024
Al2O3	32.360	22.936	13.650	22.106	31.630	24.359	24.496	14.755	13.650
TiO2	0.452	0.526	2.057	0.328	0.159	0.548	0.117	1.520	2.057
Cr2O3	31.826	42.659	44.714	44.087	33.597	41.207	40.240	44.074	44.714
FeO	18.888	20.698	25.809	21.416	18.613	17.128	21.854	27.155	25.809
NiO	0.119	0.034	0.196	0.091	0.119	0.130	0.105	0.189	0.196
MnO	0.156	0.354	0.245	0.301	0.198	0.191	0.578	0.283	0.245
MgO	15.943	11.068	12.710	8.570	10.565	13.619	9.948	10.038	12.710
CaO	0.033	0.018	0.000	0.035	0.046	0.025	0.064	0.088	0.000
Na2O	0.000	0.000	0.000	0.033	0.056	0.000	0.000	0.000	0.000
K 2O	0.007	0.008	0.014	0.013	0.028	0.026	0.002	0.016	0.014
Total	99.820	98.370	99.419	97.026	95.032	97.294	97.413	98.250	99.419

cation O									
SiO2	0.001	0.002	0.001	0.002	0.001	0.002	0.000	0.004	0.001
Al2O3	0.952	0.675	0.402	0.650	0.931	0.717	0.721	0.434	0.402
TiO2	0.011	0.013	0.052	0.008	0.004	0.014	0.003	0.038	0.052
Cr2O3	0.628	0.842	0.883	0.870	0.663	0.813	0.794	0.870	0.883
FeO	0.263	0.288	0.359	0.298	0.259	0.238	0.304	0.378	0.359
NiO	0.002	0.000	0.003	0.001	0.002	0.002	0.001	0.003	0.003
MnO	0.002	0.005	0.003	0.004	0.003	0.003	0.008	0.004	0.003
MgO	0.396	0.275	0.315	0.213	0.262	0.338	0.247	0.249	0.315
CaO	0.001	0.000	0.000	0.001	0.001	0.000	0.001	0.002	0.000
Na2O	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000
K 2O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	2.256	2.101	2.017	2.048	2.126	2.127	2.080	1.982	2.017

cation O=4									
Si	0.001	0.002	0.001	0.001	0.001	0.002	0.000	0.004	0.001
Al	1.126	0.857	0.531	0.847	1.167	0.899	0.924	0.584	0.531
Ti	0.010	0.013	0.051	0.008	0.004	0.013	0.003	0.038	0.051
Cr	0.743	1.069	1.167	1.133	0.832	1.020	1.018	1.171	1.167
Fe	0.466	0.549	0.712	0.582	0.487	0.448	0.585	0.763	0.712
Ni	0.003	0.001	0.005	0.002	0.003	0.003	0.003	0.005	0.005
Mn	0.004	0.010	0.007	0.008	0.005	0.005	0.016	0.008	0.007
Mg	0.701	0.523	0.625	0.415	0.493	0.635	0.475	0.503	0.625
Ca	0.001	0.001	0.000	0.001	0.002	0.001	0.002	0.003	0.000
Na	0.000	0.000	0.000	0.002	0.003	0.000	0.000	0.000	0.000
K	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.001	0.001
Total	3.055	3.023	3.100	3.002	2.998	3.027	3.026	3.080	3.100

Fe ⁺	0.450	0.533	0.617	0.574	0.485	0.428	0.595	0.694	0.617
Fe ²⁺	0.305	0.471	0.355	0.575	0.499	0.358	0.529	0.481	0.355
Fe ³⁺	0.145	0.062	0.262	0.000	-0.014	0.069	0.066	0.213	0.262
Mg#(Mg/(Mg+Fe ²⁺))	0.697	0.526	0.638	0.419	0.497	0.639	0.473	0.511	0.638
Cr#(Cr/(Al+Cr))	0.397	0.555	0.687	0.572	0.416	0.532	0.524	0.667	0.687
Fe ³⁺ 3#(Fe ³⁺ /Cr+Al+Fe ³⁺)	0.072	0.031	0.134	0.000	-0.007	0.035	0.033	0.108	0.134
Al3#(Al/Cr+Al+Fe ³⁺)	0.559	0.431	0.271	0.428	0.588	0.452	0.460	0.297	0.271
Cr3#(Cr/(Cr+Al+Fe ³⁺))	0.369	0.538	0.595	0.572	0.419	0.513	0.507	0.595	0.595
Cr#(Cr/(Al+Cr))	0.397	0.555	0.687	0.572	0.416	0.532	0.524	0.667	0.687
TiO2wt%	0.452	0.526	2.057	0.328	0.159	0.548	0.117	1.520	2.057

Sample No.	MSR4-2-17	MSR4-2-17	MSR4-2-18	MSR4-2-18	MSR4-2-18	MSR4-2-18	MSR4-2-19	MSR4-2-19	MSR4-2-20
SiO ₂	0.046	0.021	0.061	0.009	0.132	0.087	0.095	0.077	0.043
Al ₂ O ₃	22.106	31.630	24.359	24.496	14.755	11.626	20.958	12.769	18.367
TiO ₂	0.328	0.159	0.548	0.117	1.520	2.494	0.077	2.103	1.572
Cr ₂ O ₃	44.087	33.597	41.207	40.240	44.074	44.725	47.364	44.205	44.353
FeO	21.416	18.613	17.128	21.854	27.155	28.028	18.137	26.632	21.129
NiO	0.091	0.119	0.130	0.105	0.189	0.128	0.068	0.143	0.106
MnO	0.301	0.198	0.191	0.578	0.283	0.257	0.370	0.315	0.134
MgO	8.570	10.565	13.619	9.948	10.038	11.400	12.070	10.615	13.825
CaO	0.035	0.046	0.025	0.064	0.088	0.048	0.081	0.000	0.000
Na ₂ O	0.033	0.056	0.000	0.000	0.000	0.010	0.051	0.050	0.060
K ₂ O	0.013	0.028	0.026	0.002	0.016	0.018	0.000	0.034	0.000
Total	97.026	95.032	97.294	97.413	98.250	98.821	99.271	96.943	99.589
cation O									
SiO ₂	0.002	0.001	0.002	0.000	0.004	0.003	0.003	0.003	0.001
Al ₂ O ₃	0.650	0.931	0.717	0.721	0.434	0.342	0.617	0.376	0.540
TiO ₂	0.008	0.004	0.014	0.003	0.038	0.062	0.002	0.053	0.039
Cr ₂ O ₃	0.870	0.663	0.813	0.794	0.870	0.883	0.935	0.872	0.875
FeO	0.298	0.259	0.238	0.304	0.378	0.390	0.252	0.371	0.294
NiO	0.001	0.002	0.002	0.001	0.003	0.002	0.001	0.002	0.001
MnO	0.004	0.003	0.003	0.008	0.004	0.004	0.005	0.004	0.002
MgO	0.213	0.262	0.338	0.247	0.249	0.283	0.299	0.263	0.343
CaO	0.001	0.001	0.000	0.001	0.002	0.001	0.001	0.000	0.000
Na ₂ O	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001
K ₂ O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	2.048	2.126	2.127	2.080	1.982	1.970	2.117	1.945	2.098
cation O=4									
Si	0.001	0.001	0.002	0.000	0.004	0.003	0.003	0.003	0.001
Al	0.847	1.167	0.899	0.924	0.584	0.463	0.777	0.515	0.687
Ti	0.008	0.004	0.013	0.003	0.038	0.063	0.002	0.054	0.038
Cr	1.133	0.832	1.020	1.018	1.171	1.195	1.178	1.196	1.113
Fe	0.582	0.487	0.448	0.585	0.763	0.792	0.477	0.762	0.561
Ni	0.002	0.003	0.003	0.003	0.005	0.003	0.002	0.004	0.003
Mn	0.008	0.005	0.005	0.016	0.008	0.007	0.010	0.009	0.004
Mg	0.415	0.493	0.635	0.475	0.503	0.574	0.566	0.542	0.654
Ca	0.001	0.002	0.001	0.002	0.003	0.002	0.003	0.000	0.000
Na	0.002	0.003	0.000	0.000	0.000	0.001	0.003	0.003	0.004
K	0.001	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.000
Total	3.002	2.998	3.027	3.026	3.080	3.105	3.020	3.090	3.063
Fe ⁺	0.574	0.485	0.428	0.595	0.694	0.673	0.483	0.663	0.489
Fe ²⁺	0.575	0.499	0.358	0.529	0.481	0.394	0.435	0.430	0.327
Fe ³⁺	0.000	-0.014	0.069	0.066	0.213	0.279	0.048	0.233	0.162
Mg#(Mg/(Mg+Fe ²⁺))	0.419	0.497	0.639	0.473	0.511	0.593	0.565	0.557	0.667
Cr#(Cr/(Al+Cr))	0.572	0.416	0.532	0.524	0.667	0.721	0.603	0.699	0.618
Fe ³⁺ 3#(Fe ³⁺ /Cr+Al+Fe ³⁺)	0.000	-0.007	0.035	0.033	0.108	0.144	0.024	0.120	0.083
Al3#(Al/Cr+Al+Fe ³⁺)	0.428	0.588	0.452	0.460	0.297	0.239	0.388	0.265	0.350
Cr3#(Cr/(Cr+Al+Fe ³⁺))	0.572	0.419	0.513	0.507	0.595	0.617	0.588	0.615	0.567
Cr#(Cr/(Al+Cr))	0.572	0.416	0.532	0.524	0.667	0.721	0.603	0.699	0.618
TiO ₂ wt%	0.328	0.159	0.548	0.117	1.520	2.494	0.077	2.103	1.572

Sample No. MSR4-2-21-1;MSR4-2-21-2;MSR4-2-21-3;MSR4-2-22-1;MSR4-2-22-4

SiO2	0.000	0.025	0.086	0.091	0.226
Al2O3	25.386	17.889	30.021	33.676	9.600
TiO2	0.060	0.171	0.500	0.030	1.957
Cr2O3	42.930	47.195	35.886	32.977	44.818
FeO	21.320	18.081	17.087	17.140	34.171
NiO	0.011	0.053	0.142	0.117	0.147
MnO	0.218	0.578	0.232	0.301	0.322
MgO	9.944	15.156	16.073	13.453	8.328
CaO	0.000	0.195	0.044	0.055	0.046
Na2O	0.000	0.000	0.000	0.000	0.026
K 2O	0.019	0.025	0.008	0.020	0.000
Total	99.888	99.368	100.079	97.860	99.641

cation O

SiO2	0.000	0.001	0.003	0.003	0.008
Al2O3	0.747	0.526	0.883	0.991	0.282
TiO2	0.002	0.004	0.013	0.001	0.049
Cr2O3	0.847	0.931	0.708	0.651	0.885
FeO	0.297	0.252	0.238	0.239	0.476
NiO	0.000	0.001	0.002	0.002	0.002
MnO	0.003	0.008	0.003	0.004	0.005
MgO	0.247	0.376	0.399	0.334	0.207
CaO	0.000	0.003	0.001	0.001	0.001
Na2O	0.000	0.000	0.000	0.000	0.000
K 2O	0.000	0.000	0.000	0.000	0.000
Total	2.143	2.103	2.250	2.225	1.913

cation O=4

Si	0.000	0.001	0.003	0.003	0.008
Al	0.930	0.667	1.047	1.188	0.394
Ti	0.001	0.004	0.011	0.001	0.051
Cr	1.055	1.181	0.840	0.780	1.233
Fe	0.554	0.479	0.423	0.429	0.994
Ni	0.000	0.001	0.003	0.003	0.004
Mn	0.006	0.015	0.006	0.008	0.009
Mg	0.461	0.715	0.709	0.600	0.432
Ca	0.000	0.007	0.001	0.002	0.002
Na	0.000	0.000	0.000	0.000	0.002
K	0.001	0.001	0.000	0.001	0.000
Total	3.007	3.071	3.043	3.013	3.129

Fe ⁺	0.557	0.486	0.406	0.435	0.901
Fe ²⁺	0.540	0.301	0.292	0.401	0.555
Fe ³⁺	0.017	0.185	0.115	0.034	0.347
Mg#(Mg/(Mg+Fe ²⁺))	0.460	0.703	0.708	0.599	0.438
Cr#(Cr/(Al+Cr))	0.531	0.639	0.445	0.396	0.758
Fe ³⁺ 3#(Fe ³⁺ /Cr+Al+Fe ³⁺)	0.008	0.091	0.057	0.017	0.176
Al3#(Al/Cr+Al+Fe ³⁺)	0.465	0.328	0.523	0.593	0.200
Cr3#(Cr/(Cr+Al+Fe ³⁺))	0.527	0.581	0.420	0.390	0.625
Cr#(Cr/(Al+Cr))	0.531	0.639	0.445	0.396	0.758
TiO2wt%	0.060	0.171	0.500	0.030	1.957



VITA

Mr. Nattapol Srinak was born in Bangkok on March 29, 1976. In 1995, he was chosen to study in Chulalongkorn University where he has received the scholarship of the Excellence Sports Project (Chang Phuek Project) of Chulalongkorn University. In 1999, he graduated with a B.Sc. degree in Geology, Faculty of Science, Chulalongkorn University. After graduated, he studied the M.Sc. program in Geology at the Graduate School, Chulalongkorn University. During he studied the M.Sc. program, he was worked Groundwater Map of Province on 1:100,000 scale Project with Layne (Thailand) Limited. Now, he working with Electricity Generating Authority of Thailand (EGAT).