MITT.ÖSTERR.MINER.GES. 149 (2004)

PETROGRAPHY AND GEOCHEMISTRY OF METASEDIMENTARY, IMPACTOCLASTIC AND GRANITOID ROCKS FROM DIVERSE GEOLOGICAL SETTINGS

by

Crispin Katongo

Dissertation zur Erlangung des Doktorgrades an der
Formal- und Naturwissenschaftlichen Fakultät der Universität Wien

Institut für Geologische Wissenschaften
Wien, 2004

Abstract

This thesis present results of petrographie and geochemical studies on rocks from diverse geological settings.The rocks studied range from impactoclastic, metasedimentary and granitoid rocks.Several spectroscopic analytical techniques were used to obtain whole-rock chemical compositions, including instrumental neutron activation analysis (INAA), X-ray fluorescence spectrometry (XRF), and atomic absorption spectrometry (AAS), whereas mineral compositions were determined by electron microprobe analysis (EMPA). Age determination by the U- Pb zircon method was achieved by thermal ionization mass spectrometry (TIMS) and secondary ionization mass spectrometry (SIMS). The operating principles of each of these analytical methods are described. Because most of the thesis is concerned with various aspects of meteoritic impact cratering and shock metamorphism, an outline of impact cratering processes is also presented. Because of the diversity of the geological problems addressed in this thesis, objectives, results and conclusions of each study are presented separately.

1)The Lukanga Swamp, in central Zambia, was previously proposed as the site of a large (52 km diameter) impact structure on the basis of alleged observation of shock-diagnostic planar deformation features (PDFs). The main objective of this study was to confirm or discount the meteoritic impact origin of the Lukanga Swamp. Petrographic studies showed that the alleged planar features in quartz were not PDFs, but widely spaced, randomly oriented, subparallel, non-planar fluid inclusion trails. Siderophile element abundances such as Cr, Ni, and Co in rocks around the swamp that may indicate extraterrestrial contamination of target rocks were normal for quartz-rich crustal rocks. Similarly, neither aeromagnetic nor seismic data indicated an impact origin of the swamp. Regional structural data synthesis suggested that the Swamp may be of tectonic origin due to reactivation of movements along the major dislocation zones such as the Nyama and Kapiri-Mposhi Dislocation Zones.

2) The Crow Creek Member of the Upper Cretaceous Pierre Shale Formation of eastern South Dakota and northeastern Nebraska contains shock-metamorphosed minerals from the 74-Ma Manson impact structure (MIS). The study was aimed at evaluating the variation of ejekta thickness with distance from the MIS, estimating shock pressures from planar deformation features in shocked quartz, determing meteoritic contamination , if any, in the layer and tracing the source of the ejecta material through the mineralogy and bulk-chemistry of the ejecta. Samples from the Gregory 84-21 core, Iroquois core and Wakonda lime quarry were studied. Contents of siderophile elements could not unambiguously confirm an extraterrestrial component in the Crow Creek Member. PDF measurements on shocked quartz grains recovered mainly from the basal- unit samples of the Gregory 84-21 core indicated shock pressures of at least 15 Gpa.
Results of major and trace element abundances and elemental ratios critical to provenance studies coupled with accessory mineral compositions, suggested that the source rocks of the Crow Creek Member were of mixed provenance, ranging from quartzose, intermediate and mafic compositions derived in part from the MIS region. The expected ejekta thicknesses at the sampled locations (409 to 219 km from Manson) were calculated to range from ca. 1.9 to 12.2cm (for the present-day crater radius of Manson), or 0.4 to 2.4 cm (for the estimated transient cavity radius). The trend agreed with the observed thicknesses of the basal unit of the Crow Creek Member,but the actually observed thicknesses are larger than the calculated ones,indicating that not the entire basal unit comprises impact ejekta.

3) There are several pre-orogenic Neoproterozoic granitoid and metavolcanic rocks in the Lufilian-Zambezi belt in Zambia ans Zimbabwe that are interpreted to have been emplaced in a contintental rift setting that is associated with the break-up of Rodinia Supercontinent. Petrographic and whole-rock chemical analyses of Nchanga granite, Lusaka granite, Ngoma gneiss, metarhyodacites, Munali hills granite and Mpande gneiss, from the Zambian part of the belt were conducted in order to evaluate their chemical characteristics, and tectonic emplacement settings. The geological setting, mineralogical and geochemical features (calcalkaline and peraluminous-metaluminous compositions) indicated that these rocks are not true continental rift granitoids as previously suggested, but exhibit inherited source characteristics of calcalkaline granitic precursor rocks previously emplaced in a continental arc setting. A U-Pb zircon age of 1116.3 ± 1.7 Ma age of the Munali hills granite was also obtained, which indicated that some supracrustal rocks in the Zambesi belt of Zambia, which were previously thought to be Neoproterozoic in age, could well be Mesoproterozoic in age or older and places new constraints on regional correlations and tectono-thermal activity in the Lufilian-Zambesi belt.

4) Scapolite is a notable aspect of metamorphism in the Lufilian-Zambesi belt. metamorphism in the belt generally ranged from greenschist facies to amphibolite facies, but locally reached up to eclogite facies. Scapolite is widespread in calc-silicates,marbles, amphibolites and metagabbros and rare granitoid that are metamorphosed at low metamorphic grades. Scapolite was observed in the Munali hills granite gneiss. Both field petrographic studies of the granite gneiss, and associated rocks from the Munali hills area indicated that scapolization was due to metasomatic processes. The scapolite occurs as a pervasive replacement of plagioclase in mineral assemblages that are indicative of amphibolite facies metamorphism. Results of mineral analyses showed that all the scapolites have calcian-marialite cvompositions, which range from 27-47 Me% and Cl varying from 0.37-0.50 a.p.f.u.

The composition of scapolite is similar to that of the Copperbelt region where there is evidence of evaporite horizons. Moderate to high NaCl salinity, which range from 0.2 – 0.5 moles, and high contens of Cl in scapolite indicate that metamorphism in the belt was accompanied by NaCl-rich fluids, which were derived from evaporite horizons that existed in the metasedimentary succession in the area.