HEAVY MINERAL ANALYSIS OF SANDSTONES BY RIETVELD ANALYSIS

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The major constituents of sandstones are quartz and feldspar grains, and in some cases lithic (rock) fragments. The nature and relative abundances of these grains reflect the source area and the transportation history. Sandstones also contain minor abundances of heavy mineral grains (those with densities greater than 2.85 g/cm³). These heavy minerals also reflect the source area because different rock types contain different assemblages of these minerals. The heavy minerals, many of which are resistant, can be very useful for determination of the source and for correlation. The typical methodology for heavy mineral analysis involves: (1) sieving sand grains to obtain a particular size range within the fine to medium sand range, (2) density separation of heavy minerals using a heavy liquid (density of 2.85 g/cm³), and (3) mounting the heavy mineral grains and counting the number of grains of each mineral using transmitted light microscopy. One problem that is inherent in this method is that identification of the minerals by transmitted-light microscopy is difficult even for experienced petrographers. Also, even though a restricted sand size range is characterized, counting the number of grains of a particular mineral may not correlate well with its actual volume percentage.

This study focused on development of a methodology for quantifying heavy minerals by XRD and the Rietveld method. Rietveld refinement of XRD data should yield accurate mineral percentages. Also, because compositional information can be obtained on solid solution minerals, the Rietveld method yields more detailed information about the source rock(s) and allows more detailed correlation (or differentiation) of sandstones.

The Rietveld heavy mineral method has been tested using an Eocene sandstone from the Medicine Pole Hills (MPH) south of Rhame, North Dakota. The success of the Rietveld method is evaluated by comparison with weight percentages based on volume percentages (number and size of grains) and calculated densities of each heavy mineral. Heavy mineral identifications and densities are based on microanalysis of numerous grains using a scanning electron microscope and an energy dispersive X-ray analysis system (SEM/EDX). The SEM/EDX work shows that the heavy minerals in the MPH sandstone consist of Ca-Mg-Fe pyroxene, calcic amphibole, almandine-rich garnet, and a few less abundant phases including Mg-Fe pyroxene and Fe-Ti oxide. Some quartz and feldspar are also found in the heavy mineral fraction because of less than perfect separation and/or their presence in composite grains with heavy minerals. In addition, the XRD results show several minor phases, such as hematite and goethite, which likely occur as inclusions within the heavy mineral grains or as weathering products.

Results of Rietveld refinements will be compared with SEM/EDX results to evaluate the success of the Rietveld method in quantifying heavy minerals and in determination of the compositions of solid solution phases.