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THE WISCONSIN MAGMATIC TERRANE: AN EARLY PROTEROZOIC GREENSTONE-GRANITE TERRANE FORMED BY PLATE TECTONIC PROCESSES; Klaus J. Schulz, U.S. Geological Survey, Reston, VA 22092 and Gene L. LaBerge, Department of Geology, University of Wisconsin-Oshkosh, Oshkosh, WS 54901 and U.S. Geological Survey

The Wisconsin magmatic terrane (WMT) is an east trending belt of dominantly volcanic-plutonic complexes of Early Proterozoic age (~1850 m.y.) that lies to the south of the Archean rocks and Early Proterozoic epicratonic sequence (Marquette Range Supergroup) in Michigan. It is separated from the epicratonic Marquette Range Supergroup by the high-angle Niagara fault, is bounded on the south, in central Wisconsin, by Archean gneisses, is truncated on the west by rocks of the Midcontinent rift system, and is intruded on the east by the post-orogenic Wolf River batholith.

Although the history of the WMT is complex in detail, integration of recent studies (Sims and others, in press) provides an overview of its nature and evolution. The WMT shows many similarities to Archean greenstone-granite (AGG) terranes (Condie, 1981). In fact, until recent U/Pb zircon dating, considerable controversy existed as to the age of the rocks of the WMT. Insofar as the comparisons between the WMT and AGG terranes are valid, understanding of the tectonics of the WMT may provide important insights into the tectonic processes involved in the evolution of at least some AGG terranes.

As in many AGG terranes, a major portion of the WMT is comprised of volcanic rocks and lesser volcanogenic sediments variably metamorphosed to lower greenschist to amphibolite facies. The supracrustal rocks show a complex stratigraphy with at least three successions distinguished on the basis of differences in composition, metamorphism, and structural fabric (LaBerge and Myers, 1984; Sims and others, in press). The older units are dominantly subaqueous basaltic lavas and consanguineous intrusive rocks which are overlain locally by intermediate to felsic volcanic and volcaniclastic units, some in part subaerial (LaBerge and Myers, 1984). Both bimodal (basalt-rhyolite) and calc-alkaline (basaltic andesite through rhyolite) suites are present with the former hosting volcanogenic massive sulfide deposits (May and Schmidt, 1982). Komatiites have not been recognized within the WMT. The older basaltic units are dominantly tholeiitic in character, show strong to moderate depletion of light REE elements ($[La/Yb]_N$=0.09-0.89) and high-field-strength elements (Hf, Zr, Ta, etc.), and are lithologically and compositionally similar to recent back-arc basin basalts (e.g. Mariana Trough, Wood and others, 1981), island-arc tholeiites (e.g. Scotia arc, Hawkesworth and others, 1977), and some ophiolitic basalts (e.g. Troodos, Kay and Senechal, 1976). The younger calc-alkaline units are enriched in LIL elements ($[La/Yb]_N$=2.5-9.5), are also depleted in high-field-strength elements, and are similar to volcanic sequences found in recent island-arcs (e.g. Sunda Arc, Whitford and others, 1979).

Sedimentary rocks are locally found to overlie and(or) interfinger with the volcanic succession. They include graywacke, argillite, thin iron-formation, chert, and minor conglomerate, some containing granitoid boulders (LaBerge and Myers, 1984).

Intrusive rocks within the WMT appear to have been largely diapirically emplaced and show a temporal progression from gabbro and diorite through tonalite and granite. They range from calcic to calc-alkaline in character, although locally slightly alkaline varieties are also present (Sims and others, 1985). The granitoids show an overall increase from north to south across the terrane in their average K_2O/Na_2O ratios and SiO_2 contents. Gneissic rocks, found in domes and block uplifts, are mostly tonalite to granodiroite and are also calc-alkaline (Sims and others, 1985). Both lithologically and chemically, the WMT granitoids appear similar to those formed at compressional plate-margins (Brown, 1982).

Ultramafic rocks are present in the WMT, particularly along the northern and southern margins. They are mostly serpentinized, but perioditic and pyroxenitic lithologies are recognized. These ultramafic rocks are often spatially associated with gabbroic rocks and were in some cases structurally implaced. The ultramafic-gabbroic bodies are lithologically and chemically similar to recent ophiolitic fragments.

Structure within the WMT is complex and consists regionally of large structural blocks having diversely oriented internal structures that are bounded by ductile deformation zones ("shear zones"; LaBerge and Myers, 1984; Sims and others in press). Within the blocks, the supracrustal rocks show generally steep dips and open to isoclinal folds. The deformation zones bounding the blocks record pronounced flattening in the foliation planes and a strong component of verticle movement (Palmer, 1980). This intense deformation along zones is regional in scope, and generally younger than the pervailing internal structural fabric within the blocks. Domes along the northern margin of the terrane, representing large-scale, antiformal fold-interference structures, modified by diapirism and by intrusion of granitoids, have further deformed and metamorphosed the mantling supracrustal rocks (Sims and others, 1985).

U-Th-Pb zircon ages on the volcanic and associated gneissic and granitoid rocks that comprise the WMT (VanSchmus, 1980; Sims and others, in press) indicate that they formed from 1,890 to 1,830 Ma. Detailed isotopic dating in the northeastern portion of the WMT (Sims and others, 1985) indicates that volcanism, granitoid intrusion, metamorphism, and deformation within this region occurred from 1,865 to 1,835 Ma ago, a time span of 30 m.y.

The overall lithologic, geochemical, metallogenic, metamorphic, and deformational characteristics of the WMT are similar to those observed in recent volcanic arc terranes formed at sites of plate convergence. It is concluded that the WMT represents an evolved oceanic island-arc terrane accreated to the Superior craton in the Early Proterozoic. This conclusion is strengthened by the apparent absence of Archean basement from most of the WMT, and the recent recognition of the passive margin character of the epicratonic Marquette Range Supergroup (Larue and Sloss, 1980). On the basis of the new data for the WMT and the epicratonic sequence in Michigan, Schulz and others (in press) have proposed the following tectonic model: 1) early crustal rifting and spreading along the southern margin of the Superior craton, 2) subsequent subduction and formation of a complex volcanic arc, and, 3) with oblique convergence, collision of the arc with the continental margin (epicratonic) sequence and Archean crust of upper Michigan culminating in the Penokean orogeny. This tectonic model is similar to plate tectonic histories recently presented for other Early Proterozoic terranes of North America (Hoffman, 1980; Lewry, 1981; Karlstrom and others, 1983). This indicates that the events and processes occurring in the Lake Superior region were not unique, and that the tectonic processes operating were generally similar to those recognized for the Phanerozoic. Given the general similarity of some AGG terranes to the Early Proterozoic magmatic terranes, it seems likely that subduction and plate collisions were also operative in the Archean.

References:

Brown, G. C., 1982, In: Thorpe, R. S., ed., Andesites: New York, John Wiley and Sons, p. 437-461.

Condie, K. C., 1981, Archean Greenstone Belts: Elsevier Scientific Publ. Co., New York, 434 p.

Hawkesworth, C. J., O'Nions, R. K., Pankhurst, R. J., Hamilton, P. J., and Evensen, N. M., 1977, Earth and Planet, Sci. Letters, v. 36, p. 253-262.

Hoffman, P. F., 1980, In: Strangway, D. W., ed., Geol. Assoc. Canada Special Paper 20, p. 523-549.

Karlstrom, K. E., Flurkey, A. J., and Houston, R. S., 1983, Geol. Soc. America Bull., v. 94, p. 1257-1274.

Kay, R. W., and Senechal, R. G., 1976, Journal Geophy. Research, v. 81, p. 964-970.

LaBerge, G. L., and Myers, P. E., 1984, Geol. Soc. America Bull., v. 95, p. 246-253.

Larue, D. K., and Sloss, L. L., 1980, Geol. Soc. America Bull., Part I, v. 91, p. 450-452.

Lewry, J. F., 1981, Nature, v. 294, p. 69-72.

May, E. R., and Schmidt, P. G., 1982, Geol. Assoc. Canada Spec. Paper 25, p. 447-480.

Palmer, E. A., 1980, Unpublished M.S. thesis, Univ. of Minnesota-Duluth, Duluth, Mn, 127 p.

Schulz, K. J., Sims, P. K., Morey, G. B., in press, Precambrian: Conterminous U.S., DNAG v. C-2, Geol. Soc. America.

Sims, P. K., Peterman, Z. E., and Schulz, K. J., 1985, Geol. Soc. America Bull., v. 96, p. 1101-1112.

Sims, P. K., Schulz, K. J., Peterman, Z. E., and VanSchmus, W. R., in press, Precambrian: Conterminous U.S., DNAG v. C-2, Geol. Soc. America.

VanSchmus, W. R., 1980, In: Morey, G. B., and Hanson, G. N., eds., Geol. Soc. America Special Paper 182, p. 159-168.

Whitford, D. J., Nicholls, I. A., and Taylor, S. R., 1979, Contrib. Mineral Petrol., v. 70, p. 341-356.

Wood, D. A., Marsh, N. G., Tarney, J., Joron, J.-L., Fryer, P., and Treuil, M., 1981, In: Hussong, D. M., and Uyeda, S., and others (eds.) Init. Rep. Deep Sea Drilling Proj. 60, p. 611-645, U.S. Government Printing Office, Washington, D. C.