Metasomatism

JOHN RAKOVAN
Department of Geology
Miami University
Oxford, Ohio 45056
rakovajf@muohio.edu

"Dry bone" smithsonite ore, metasomatically replaced limestone from the Graphic mine, Magdalena mining district, Socorro County, New Mexico. Virgil Lueth photo.

One of the hallmarks of geology, as with most things in life, is change. The minerals, and the rocks that they compose, which sit so stoically in an outcrop or on a collector's shelf, seem eternal on the scale of human lives but are ephemeral in geologic time. This is the essence of the *rock cycle*—rocks change, from one type to another and back again. When they change because of an increase in the pressure and/or temperature of their surroundings, it is called *metamorphism*. When metamorphism is accompanied by a change in the chemistry of a rock, the rock is said to have been *metasomatized* (Best 1982). Thus, metasomatism involves changes in mineralogy and structure along with the addition and/or removal of elemental constituents from a rock. At very high temperatures this can be accomplished simply by diffusion of constituents through the solid rock. Much more commonly, however, metasomatism involves chemical exchange with fluids; in the earth's crust these fluids are usually aqueous solutions. This is yet another example of the importance of water in the formation of minerals and rocks (see previous Word to the Wise columns: hydrothermal, hypogene-supergene, and placer).

During metasomatism the minerals that make up the original rock are partially or completely replaced by new minerals. The susceptibility of a rock to metasomatism depends partly on its mineralogical and structural characteristics and partly on the characteristics of the fluid (i.e., temperature, pressure, pH, oxygen-reduction potential, and water/rock ratio). For example, limestone, which is considerably more soluble than most other rock types, is especially vulnerable to metasomatic changes. An excellent example of metasomatism is the formation of a skarn (Rakovan 2003), wherein Si from an intruded magma is added to a limestone, usually through the activity of hydrothermal fluids, and combines with Ca to form the Ca-silicate minerals characteristic of skarns.

Hydrothermal activity and metasomatism often go hand in hand. In many cases the dissolved ions that precipitate to form hydrothermal mineral deposits are derived from the interaction of these waters and the rocks through which they have moved. The removal of solutes leaves the parent rocks hydrothermally altered or metasomatized. Several articles in this issue of *Rocks & Minerals* (see Cook; Jensen; Ottens and Cook) discuss mineral deposits that are hosted by or associated with metasomatic rocks. The original minerals in these rocks have been altered to new minerals by chemical replacement through interaction with the ore-forming hydrothermal fluids. An understanding of the nature of metasomatic alteration is useful because it can yield information about the origins and physical conditions of the ore-forming fluids (Barnes 1997).

In some examples of metasomatism the texture and structure of the original rock may be completely obliterated. For example, an igneous rock may be entirely replaced by massive crystalline quartz. It is similarly common, however, to find that the structure of the original rock is preserved even though its mineralogy has been entirely altered. This is the result of *pseudomorphic replacement* of the original minerals.

A classic example with an interesting history is the metasomatic replacement of limestones in the Magdalena mining district in Socorro County, New Mexico (Loughlin and Koschmann 1942). Home of the famous Kelly mine, this district is typically associated with zinc, although it was originally founded for lead ore. The hydrothermal fluids responsible for the formation of the deposits carried lead, zinc, and other solutes into the rocks that today host mineralization. Interaction between the limestones and these fluids resulted in the partial to complete replacement of calcite, $Ca(CO)_3$, by smithsonite, $Zn(CO_3)$. Most of the smithsonite in the district is not the beautiful blue variety coveted by collectors, but rather is milky white and almost indistinguishable in hand specimen from the calcite of the original limestone. The replacement preserved the texture of the original lime-

Dr. John Rakovan, an executive editor of Rocks & Minerals, *is a professor of mineralogy and geochemistry at Miami University in Oxford, Ohio.*

stone in such intricate detail that it went unnoticed for many years (see fig.). In fact, the abundant lead ore and the absence of zinc perplexed geologists who knew about these types of deposits. During early mining in the district, the "barren" limestone was dumped in the mine dumps until it was discovered that this was no longer limestone but, as a result of metasomatism, was a rich ore, smithsonite, containing the "missing" zinc. This discovery is well noted in the memoirs of Asa B. Fitch (ca. 1905), manager and lessee of the Graphic mine (Bob Eveleth, pers. com., 2004). Early on, Fitch had noted the unusual weight of the then-unrecognized metasomatized limestone and had it assayed for lead, of which it showed no trace. He subsequently forgot about this observation until years later the question of the missing zinc became important. On a hunch, he sent similar samples in for zinc determination. Latter that day an excited young assayer reported that the "limestone" samples contained 37 percent and 38 percent zinc!

ACKNOWLEDGMENTS

I would like to thank Bill Hart and Kendall Hauer for their reviews of this column and Bob Eveleth for information on the history of mining and ore development in the Magdalena mining district in Socorro County, New Mexico.

REFERENCES

Barnes, H. B. 1997. *Geochemistry of hydrothermal ore deposits.* New York: John Wiley & Sons.

Best, M. G. 1982. *Igneous and metamorphic petrology.* New York: W. H. Freeman and Co.

Loughlin, G. F., and A. H. Koschmann. 1942. *Geology and ore deposits of the Magdalena mining district, New Mexico.* U.S. Geological Survey professional paper 200.

Rakovan, J. 2003. A Word to the Wise: Skarn. *Rocks & Minerals* 78: 271. ❑