NINTH V.E. McKELVEY FORUM ON MINERAL AND ENERGY RESOURCES

USGS RESEARCH ON MINERAL RESOURCES—1994 PROGRAM AND ABSTRACTS

Edited by L.M.H. Carter, M.I. Toth, and W.C. Day

ISOTOPIC TRACERS OF GOLD MINERALIZATION IN LATE PROTEROZOIC AND PALEOZOIC LIMESTONES OF SOUTHERN NEVADA

J.N. Aleinikoff, Z.E. Peterman, B.L. Widmann, M. Walter, and Kiyoto Futa

Disseminated gold deposits (Carlin-type) are important mineral exploration targets in the Great Basin. Many deposits occur in Late Proterozoic and Paleozoic limestones and dolomites that were mineralized in the Cretaceous and Tertiary by hydrothermal fluids which deposited micrometer- to submicrometer-sized gold particles. Commonly, ore deposition was structurally controlled, and in some areas shallow-dipping thrust or detachment faults were pathways for the mineralizing solutions.

Late Proterozoic and Paleozoic shelf carbonate rocks crop out extensively in the mountain ranges of southern Nevada. Bare Mountain, located about 100 miles (160 km) northwest of Las Vegas (immediately west of Yucca Mountain), is composed of heavily mineralized carbonate rock. Other ranges, such as the Striped Hills, Specter Range, and Spring Mountains, contain the same stratigraphic section, but the rocks apparently are mostly barren. We have measured Sr and Pb isotopic compositions and Sr, Rb, Pb, U, and Th concentrations in fresh (unaltered) and mineralized (altered) rocks, including samples collected along traverses that cross contacts between unaltered rocks and ore zones in an operating underground mine. The objectives of this study are to determine (1) if mineralized rock has Sr and Pb isotopic signatures indicative of fluid alteration and Carlin-type gold deposition, and (2) if these isotopic tracres can be used in exploration.

Marine limestones incorporate the $^{87}Sr/^{86}Sr$ value of sea water from which they are deposited. The oceans are isotopically uniform in strontium at any particular time, but $^{87}Sr/^{86}Sr$ values have varied systematically throughout Late Proterozoic and Phanerozoic time. However, if strontium of a different isotopic composition were added to or exchanged with strontium in the limestone, then the $^{87}Sr/^{86}Sr$ in these limestones might be significantly modified from its primary depositional value. Lead isotopic ratios ($^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$) in carbonate are a function of the age of the rock and the concentrations of Pb, U, and Th in the rock. Closed-system, modern-day Pb isotopic ratios in Paleozoic carbonate rocks are fairly high (such as $^{206}Pb/^{204}Pb > 20$).

Cretaceous and Tertiary alteration of Paleozoic carbonate rocks of southern Nevada produced an increase in Sr, Pb, U, and Th concentrations, an increase in $^{87}Sr/^{86}Sr$, and a decrease in $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$. Although these modifications of the primary isotopic compositions and concentrations could have been caused by dolomitization or exchange among units during metamorphism, the changes were most likely caused by introduction of Sr, Pb, U, and Th by hydrothermal fluids that had acquired these elements from underlying Precambrian basement rocks. Thus, anomalously high $^{87}Sr/^{86}Sr$ and Pb (ppm), and low $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$ could indicate hydrothermally altered and mineralized carbonate. For convenience and clarity, $^{87}Sr/^{86}Sr$ values are expressed as the per mil deviation ($\delta^{87}Sr$) from modern sea water $^{87}Sr/^{86}Sr$.

Both mineralized and barren Late Proterozoic and Paleozoic carbonates were collected from Bare Mountain. For comparison, suites of unmineralized samples were also collected from the Striped Hills, Spring Mountains, and various ranges in the vicinity of Indian Springs Valley. $\delta^{87}Sr$ values for Paleozoic carbonates from the Striped Hills, Spring

Mountains, and mountain ranges near Indian Springs Valley have a limited range of –1 to +2‰. Some of these values are slightly higher than would be expected for primary marine values, but we attribute this to relatively minor local exchange during dolomitization or metamorphism. In contrast, $\delta^{87}Sr$ values for Bare Mountain samples range widely and have values as high as +25‰. Low values (<+2‰) are from areas on Bare Mountain that do not appear to be mineralized or altered. $\delta^{87}Sr$ values of +3‰ or higher are from known mineralized areas such as the Sterling mine, the Gold Ace mine, Tungsten Canyon, Fluorspar Canyon, Secret Pass, and the Telluride mine. Similarly, unaltered rocks have very low Pb (0.81 ppm), U (0.35 ppm), and Th (0.78 ppm) and high Pb isotopic ratios (for example, $^{206}Pb/^{204}Pb=21.87$), whereas altered rock has high Pb (51.3 ppm) and Th (4.46 ppm) and low $^{206}Pb/^{204}Pb$ (19.08).

We conclude that hydrothermal alteration of gold-bearing Late Proterozoic and Paleozoic carbonate rocks is indicated by modifications of the Sr and Pb isotopic systematics. The isotopic ratios in the altered rocks presumably reflect the isotopic signature of underlying Precambrian basement through which the mineralizing fluids passed. Thus, we suggest that Sr and Pb isotopic tracers have considerable potential for identifying hydrothermal alteration in carbonate rocks of southern Nevada that may contain cryptic gold deposits.

JURASSIC TODILTO LIMESTONE MEMBER, FACIES, DIAGENESIS AND MINERALOGY, GRANTS URANIUM DISTRICT, NEW MEXICO

Augustus K. Armstrong

The Todilto Limestone Member, basal member of the Wanakah Formation (Middle Jurassic) of the Grants uranium district, is 1–30 ft (0.3–9.1 m) thick and records the change in depositional environments from a restricted marine embayment with an ephemeral connection to the Curtis-Summerville sea to a completely enclosed and shrinking body of gypsiferous water. The salina measured 300 miles (483 km) from east to west and 250 miles (402 km) from north to south, and was fringed by an extensive limestone-gypsum sabkha. The arenaceous-lime mudstone records a shoaling-upwards sequence deposited in subtidal to supratidal sabkha environments, in alternating brackish to hypersaline marine waters. Dolomite is absent in the study area. The calcite lime mudstones were derived primarily from an aragonite mud precursor and were subjected to extensive neomorphism. The aragonite-to-calcite diagenetic history is evident in the poorly preserved ooids.

The salina waters did not support a normal marine invertebrate fauna or flora. Bioclasts of the marine calcareous algae, dasyclads of the Tribe Salpingoporelleae, indicate short periods of near-normal marine water as a result of sea water influx into the Todilto embayment. Ostracodes lived in ephemeral-gypsiferous ponds and are abundant in the sabkha facies. The salinity of marine waters was influenced by seasonal influx from streams, by rainfall, by periods of drought, and by intermittent connections to the Curtis-Summerville sea. The overlying 0–110 ft (0–33.5 m)-thick gypsum unit found to the east of the study area was deposited in the center of the basin during the final salina phase. Lacustrine alkaline evaporites, such as trona and shortite, are not known from the Todilto Limestone Member.

Megapolygon mounds to intraformational folds of early diagenetic origin, in a vertical stack up to 10 ft (3 m) high and 45 ft (14 m) wide, occur in the supratidal facies and are associated with calcite pseudomorphs of anhydrite-gypsum and anhydrite ptygmatic-enterolithic layers. The fractures of the megapolygons may have acted as sites of preferential saline ground-water outflow. The intraformational folds are overlapped and buried by thick-bedded microbial mat, supratidal ostracode-lime mudstone. The Todilto Limestone Member was subjected to vadose solution that formed sinkholes, rundkarrens, and solution pipes that are filled with limestone breccias and ferruginous sands from the overlying Beclabito Member of the Wanakah. The smaller vadose solution cavities are partially filled with multiple cycles of spar calcite and iron-stained quartz sands. Commercial bodies of uranium ore are found in the Todilto intraformational folds and associated solution cavities. Isotopic ages (155–150 Ma) indicate that the uraninite is nearly syngenetic with the carbonates.

INTRUSION-RELATED MINERALIZATION IN MEXICO

Mark D. Barton, John-Mark G. Staude, and Lukas Zürcher

Igneous-related mineralization in Mexico can be broadly divided between (1) epithermal deposits that have broad temporal and spatial correlations with volcanism, and (2) mineralized deposits clearly associated with intrusive centers and exhibiting close relationships in composition, time, and space. We review herein patterns of intrusion-related mineralization and possible controls, based in part on continuing research and database compilation by the University of Arizona–mining industry–U.S. Geological Survey consortium on the mineral resources of Mexico.

In Mexico, intrusion-related mineral deposits are primarily Mesozoic to middle Tertiary in age. Although complex in detail, three broad periods are prominent in the mineralization record: the late Mesozoic, the Laramide, and

USGS RESEARCH ON MINERAL RESOURCES—1994
PART A—PROGRAM AND ABSTRACTS

Edited by L.M.H. Carter, M.I. Toth, *and* W.C. Day

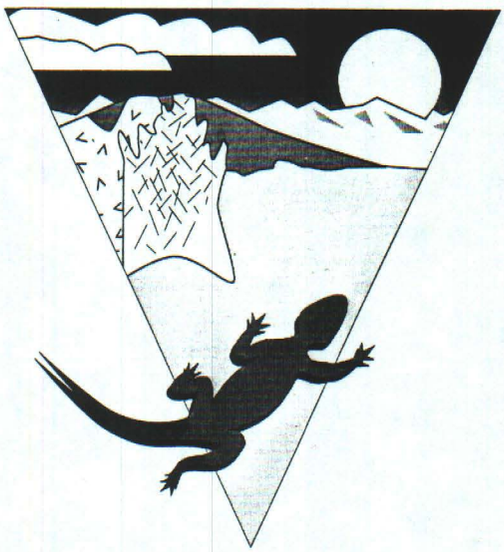
NINTH V.E. McKELVEY FORUM ON
MINERAL AND ENERGY RESOURCES

U.S. GEOLOGICAL SURVEY

Cosponsored by

Arizona Geological Society | University of Arizona | Arizona Geological Survey

9th V.E. McKelvey Forum
Mineral Resources



U.S. GEOLOGICAL SURVEY CIRCULAR 1103–A