01:50 p.m. Gray, Norman H.

BASE METAL MINERALIZATION AND DIAGENESIS IN THE HARTFORD BASIN.

GRAY, Norman H., Department of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045.

Minor occurrences of copper, lead and zinc mineralization are found throughout the Mesozoic Hartford basin. Copper is particularly widespread as i) stratabound sulfide disseminations in gray sandstones and siltstones, ii) gangue-poor solid sulfide veins, iii) copper sulfides in quartz-carbonate-barite veins, and iv) as sulfides and native copper associated with the secondary minerals of the lava flows. The stratabound copper disseminations are found almost exclusively in sedimentary rocks at or near the stratigraphic level of the Talcott Basalt, the oldest flow in the basin. Lead and zinc sulfide occurrences are always in close proximity to either the lacustrine black shales of the central basin, or the crystalline basement rocks on the margins.

The extent of the wall-rock alteration associated with the first three occurrence types is always minor against sedimentary rocks (principally silicification and dissolution of hematite) but pronounced against basalt (albite-ferroan dolomite replacement). The gangue in these occurrences consists of minerals that are found as diagenetic cements in the sediments of the basin. These facts suggest the mineralizing fluids were the diagenetic waters themselves. Because these fluids were apparently so far out of equilibrium with basalt, the source of the copper is likely to have been the sediments. Detrital ilmenite and magnetite in the arkosic sediments broke down at the earliest stages of diagenesis and released their trace amounts of copper long before the pore fluids became saturated in other diagenetic minerals. This copper seems to have been deposited as stratabound disseminations at local reducing sites in the near-surface environment. The distribution and age of these deposits suggest the convective overturn of the formation waters was driven by thermal effects of Talcott-aged intrusives. The gangue-poor vein deposits also formed at this time at favorable sites along the subsurface conduits, principally normal faults, used by the rising hydrothermal waters.

The gangue-rich quartz-calcite-barite mineralization is much later and postdates the last volcanic event in the basin. A major episode of post-Hampden normal faulting tapped the mature, warm (150-180°C) highly saline pore waters of the New Haven Arkose while the unit was still sufficiently permeable to allow large quantities waters to escape up open faults and deposit quartz, carbonate, barite, and copper en route to the surface.

02:30 p.m. Boutaleb, Mohamed

MINERALIZATION RELATED TO RIFTING IN MOROCCO: AN OVERVIEW

BOUTALEB, Mohamed, Ecole Nationale Industrie et Minieres, BP 753, Rabat Agdal, Morocco

Many periods and different styles of rifting are recorded in Morocco. Examples include, back-arc rifting events in the Precambrian, horst and graben structures formed during the Viséan (Lower Carboniferous) as part of the North-East regional structural event of the Moroccan meseta, and the long lasting, very complex, Mesozoic North Atlantic Rift.

The breaking apart of northwest Africa and North America during the early Mesozoic resulted in a highly fractured, northwest African continental margin. Rifting related to the opening of the proto-Atlantic lasted well into the Jurassic and resulted in northeast-southwest oriented horst and graben structures. Those structures are related to the Touissit Pb deposit which is hosted in limestones of the Aalenian (lower, middle Jurassic) Bajocian Formation. Lead grades are 10 to 15 % and the deposit contains minor Cu-Zn.

The stratigraphic record (mostly thick red-bed sequences and basalt flows) of the early portion of the North Atlantic Rift event is preserved in several exposed basins in the High Atlas, Middle Atlas and Moroccan meseta, as well as many buried basins in offshore Morocco. Triassic arkoses host the Zeida deposit that comprises low grade (2-4%) Pb and minor amounts of Zn, Mo, U and V. The arkoses also host stratiform Pb-Ba deposits in the Haute Moulouya. Thick evaporite sequences were deposited in many of the half and full grabens that formed during this continental rifting event. Some of the salt deposits (which include halite, K-Mg salts, anhydrite, gypsum and barite) are in production.

Ore deposits related to the earlier rifting events are represented by the Viséan Kettara Zn-Pb deposit and the late Precambrian Imitar Ag deposit. The Kettara deposit, located in the Hercynian meseta, is a massive sulfide composed principally of pyrrhotite, sphalerite, galena and pyrite. Production was primarily for sulfur. It is hosted by volcanic-sedimentary units. Imitar is hosted by metamorphosed pelites and black shales of the Anti-Atlas. In addition to about 100 tonnes of Ag per year it produces minor amounts of Hg, Zn and Pb.

03:15 p.m. Zierenberg, Robert A.

FORMATION OF THE ATLANTIS II DEEP MASSIVE SULFIDE DEPOSIT AT THE TRANSITION FROM CONTINENTAL RIFTING TO SEAFLOOR SPREADING IN THE RED SEA.

ZIERENBERG, Robert A., U.S. Geological Survey, Mail Stop 901, 345 Middlefield Rd., Menlo Park, CA 94025-3591.

Continental extension in the Red Sea region began in the early Tertiary and by late Oligocene or early Miocene a depression along the main trough of the Red Sea was invaded by marine water from the Mediterranean region. A thick sequence (2-5 km) of marine evaporites was deposited in the trough during the Miocene. Although initiation of seafloor spreading (~1.5 cm/ym) began 3-5 million years ago in the southern Red Sea, discrete seafloor spreading does not occur in the northern Red Sea. Extension in the northern Red Sea is presumably accommodated by local zones of intrusion of dikes and sills resulting in the formation of grabens along the axial zone

The Atlantis II deep is located near the transition from seafloor spreading to diffuse continental extension. Metalliferous sediment is deposited in a graben that is flanked by rifted Miocene evaporites and floored by oceanic tholeiite. The graben forms a "third-order basin" approximately 8 km wide by 15 km long that is filled with a dense brine with a salinity of 256‰ at a temperature of 62° C. The brine forms by dissolution of evaporites and is heated to approximately 350° C by interaction with basaltic rock. High temperature brine-basalt interaction forms an acidic ore fluid that transports chloride-complexed metals to the seafloor. Cooling of this fluid by mixing in the brine pool results in precipitation of metal sulfides and silicates. A series of density interfaces above the lower brine layer occur at progressively lower temperatures and salinity and higher fO_2, and allow the precipitation of first Fe-oxide then Mn-oxide as metalliferous brine diffuses and mixes with overlying oxygenated seawater. Separation of base-metal sulfide, Fe-oxide, and Mn-oxide facies metalliferous sediment forms a geochemical halo centered on the deposit. Changes in brine pool conditions, including temperature and discharge rate of inflowing brine, result in vertical facies variation in the ~20 m thickness of metalliferous sediment that covers the floor of the brine pool. The geochemistry of the hydrothermal system that forms the Atlantis II Deep deposit is similar to "black smoker" type deposits that form from buoyant hydrothermal fluids vented at sediment-free spreading centers, but the presence of a submarine brine pool forms a depositional environment that results in efficient deposition of metals in a confined area with a high potential for preservation of sulfide.

03:40 p.m. Ririe, G. Todd

STRUCTURE AND MINERALIZATION IN THE SALTON TROUGH, CALIFORNIA

RIRIE, G. Todd, Unocal Science & Technology Division, P. O. Box 76, Brea, California 92621.

The Salton Trough is located in southeastern California and extends into northern Baja, Mexico. Structurally the Salton Trough consists of predominantly northwest-trending, right-lateral, strike-slip faults separated by a series of down-dropped basinal areas. A variety of processing techniques were used to enhance gravity and magnetic data which were used to help define the structural styles present in the sediment-filled Trough, and to define the boundaries of the basinal areas. The system of strike-slip faults and related basinal areas is interpreted to be a late Neogene style of deformation that overprints an earlier-formed extensional basin.

The intrusion of Neogene intrusive rocks into the sediment-filled Salton Trough has resulted in the development of a number of geothermal systems including the Salton Sea system. A characteristic feature of the commercially productive geothermal systems in the Salton Trough is the presence of high-temperature (>250° C) saline brines. The chemistry of these brines varies widely within the Salton Trough, and also within individual systems. Data from a large number of analyses of the Salton Sea geothermal system brines and scales document the presence of a variety of metallic elements including: Pb, Zn, Cu, Mn, Ag, and Au.

A variety of mineral deposits occur within and adjacent to the Salton Trough including the large open pit Mesquite gold mine. However, none of the gold deposits along the margin of the Salton Trough formed from a fossil geothermal system analogous to the Salton Sea system. Fossil analogs to Salton Sea type systems are suggested to be present in the Proterozoic Mt. Isa block in northern Australia. Deposits in this part of Australia consist of several world-class base metal deposits including the Mt. Isa mine, and several recently discovered copper-gold deposits. Structural controls on the localization of geothermal systems in the Salton Trough may be similar to those controlling the distribution of mineralization in ancient continental rift systems such as those in northern Australia.

04:05 p.m. McKibben, Michael A.

Modern and ancient mineralization in the Salton Trough Rift

McKIBBEN, Michael A., Dept. Earth Sci., Univ. Calif., Riverside CA 92521.

The Salton Trough of SW North America is an active continental rift, the landward extension of the divergent tectonics of the Gulf of California. Shallow magmatic heat sources, thick porous sediments, tectonic activity and saline lakes interact to yield a variety of Pleistocene to modern hydrothermal systems. The Trough contains large known geothermal and mineral resources, but significant resource potential exists along its margins and southward into Baja California.

The oldest mineralization, the Fish Creek evaporite, is a $CaSO_4$ deposit formed by a pre–rift Tertiary marine incursion. Along the E margin of the rift occur disseminated epithermal Au deposits such as Mesquite, one of California's largest Au mines. Formed during the Oligocene in dilatent shear zones generated by strike-slip faulting, its location reflects a proto–rift strike–slip tectonic environment.

4–5 million years ago the prograding Colorado River delta bisected the Trough, influencing the character of Pliocene and younger hydrothermal activity. The northern part of the Trough became a closed basin filled intermittently by large freshwater lakes. Along the W margin of the rift lies the Modoc hot spring gold deposit, a shallow stockwork silica vein system overlain by sinter terraces and acid sulfate alteration. This deposit occurs at the intersection of a range–front growth fault with fossil lake levels, suggesting paleohydrologic control by ancient lakes.

Active geothermal systems within the Trough include low–T (<250°C) systems such as Heber and East Mesa, localized along high–angle faults where shallow groundwaters are conductively heated above basement highs. These blind systems have no surface expression and only moderate geophysical anomalies. Some are siliceous and gold–bearing, perhaps modern analogs for Modoc whose fluids have not yet seen the surface. High–T (>250°C) active systems occur in sediment filled pull–apart basins developed over spreading center fragments (e.g., Salton Sea, Brawley, Cerro Prieto). These systems exhibit high heat flow, strong gravity and magnetic anomalies, and often have surface manifestations such as Quaternary volcanoes and thermal features. Many contain hot metalliferous brines that have evolved in the saline lake environment of the northern Trough. The brines rise diapirically to depths of only 0.5 km as they are heated by the underlying MORB igneous activity. Their tectonic setting and evolution may be good analogs for the genesis of ancient stratiform base metal deposits in continental rift settings.