UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

GNEISS-HOSTED KYANITE GOLD AND GNEISS-HOSTED EPITHERMAL GOLD:

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Model 37c

DESCRIPTIVE MODEL OF GNEISS-HOSTED KYANITE GOLD

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BRIEF DEPOSIT MODEL

Deposit type: Gneiss-hosted kyanite gold

Compiled : March 1987

Principal commodities produced: Au Byproducts: Cu

Examples of typical deposits: Tumco mine group and American Girl-Padre Y Madre mines, Cargo Muchacho Mountains, southeastern California

Relative importance: These low grade, large tonnage deposits have been only recently discovered and insufficient data is available to assess their importance. This deposit model is based on occurrences in one mountain range and should be considered preliminary.

Descriptive/ genetic synopsis: Gold occurs in association with biotite-magnetite-quartz gneiss that form lenticular bodies subparallel to the gneissic foliation. Some bodies occupy ductile shear zones. Highly aluminous granofels and schist of metasomatic origin are spatially associated with the gold occurrences. Kyanite-quartz granofels and muscovite schist are the most common aluminous rock types; pyrophyllite schist and quartzite are less common varieties. These aluminous rocks lack any detectable gold.

Associated or related deposits: Kyanite quartzite at Willis Mountain, Virginia

General references: 1) Henshaw, P.C., 1942, Geology and mineral deposits of the Cargo Muchacho Mountains, Imperial County, California: California Journal of Mines and Geology, v. 38, p. 147-196. 2) Guthrie, J.O., Cockle, A.R., and Branham, A.D., 1987, Geology of the American Girl-Padre Y Madre gold deposits, Imperial County, California: AIME Preprint 87-87, 4 p. 3) Tosdal, R.M., and Smith, D.B., 1987, Some characteristics of gneiss-hosted gold deposits of southeastern California: U.S. Geological Survey Circular 995, p. 71. 4) Espenshade, G.H., and Potter, D.B., 1960, Kyanite, sillimanite, and andalusite deposits of the southeastern states: U.S. Geological Survey Professional Paper 336, 121p.

REGIONAL GEOLOGIC ATTRIBUTES

Tectonostratigraphic setting: Known deposits are hosted by metamorphosed silicic volcanic and plutonic rocks that now contain amphibolite facies mineral assemblages. The igneous protoliths once composed a continental margin magmatic arc.

Regional depositional environment: Metavolcanic rocks possibly represent fragments of calderas. Intruding granitic rocks and associated peraluminous pegmatites are not genetically related to the volcanic rocks. Regional metamorphism and deformation accompanied granite plutonism.

Age range: The only known deposits are probably Late Jurassic, though a Cretaceous age is also possible. Cenozoic geologic events are locally important to the genesis of an ore body. Similar deposits in the southeastern United States may be Proterozoic or Paleozoic.

LOCAL GEOLOGIC ATTRIBUTES

Host rocks: Metamorphosed silicic volcanic and granitic rocks.

Associated rocks: Aluminous schist and granofels.

Ore and gangue mineralogy: Gold is usually free-milling or associated with pyrite and chalcopyrite; galena, sphalerite, and scheelite are locally present. Gangue minerals include quartz, magnetite, calcite, white mica, biotite, chlorite, and fluorite.

Wallrock alteration: An early stage of K-feldspathization, biotitization, and silicification associated with magnetite and minor epidote and garnet is followed by a later stage of advanced argillic alteration characterized by kyanite, muscovite, biotite, quartz, and lesser rutile, magnetite, ilmenite, and tourmaline. Textural evidence indicates both alteration stages were contemporaneous with granitic plutonism and metamorphism. Younger sericite, pyrophyllite, and propylitization are associated with brittle fractures that cut the older alteration assemblages.

Structural setting: Bodies are subparallel to foliation within the metavolcanic gneiss or are along low-angle ductile shear zones between the metavolcanic gneiss and the granitic gneiss. Brittle reactivation along the low-angle shear zones are locally important.

Dimensions of ore in typical deposits: Bodies range up to 20 meters wide.

Dimmensions of alteration or distinctive halos: Unknown

Effect of weathering: Limited significance.

Effects of metamorphism: First stages of gold deposition are considered to have occurred during the waning stages of regional metamorphism and ductile shear.

Geochemical signatures: Au-Ag-Bi-W-Cu-Zn-Pb-As-Sb-F-B

Isotopic signatures: Limited oxygen isotope data suggests mixing of a metamorphic and a magmatic-meteoric fluid. Sulfur isotopes suggest an igneous source.

Fluid inclusions: Two fluid inclusion populations are present; the older is CO2-rich and the younger lacks CO2.

Geophysical signatures: Aeromagnetic anomalies are observed to correlate with the known location of the magnetite-rich bodies.

Ore controls/exploration guides: Three criteria seem to be critical for these types of deposits. These are: 1) volcanic and granitic rock as hosts; 2) regional metamorphism and deformation associated with low-angle shear zones; and 3) spatial association of high-aluminous metasomatic rocks.

DESCRIPTIVE MODEL OF GNEISS-HOSTED EPITHERMAL GOLD

By Richard M. Tosdal and David B. Smith

Deposit type: Gneiss-hosted epithermal gold

Compiled : March, 1987

Principal commodities produced: Au

Examples of typical deposit: Mesquite mine, southeastern California

Relative importance of this type of deposit: The deposit potentially represents a new type of large tonnage disseminated gold deposit. Because the knowledge of these types of deposits is incomplete, their relative importance is unknown.

Descriptive/genetic synopsis: The bulk of the gold mineralization is found in epithermal breccia- and fracture-fillings and veins that cut sub-horizontal amphibolite facies meta-volcanic and plutonic gneiss.

Associated or related deposit types: Gneiss-hosted kyanite gold deposits.

General references: 1) Manske, S.L., Matlack,W.F., Springett, M.W., Strakele,A.E.Jr.,Watowich, S.N., Yeomans, B., and Yeomans, E., 1987, Geology of the Mesquite deposit, Imperial County, California: AIME Preprint 87-107, 9 p. 2) Tosdal, R.M., and Smith. D.B., 1987, Some characteristics of gneiss-hosted gold deposits of southeastern California: U.S. Geological Survey Circular 995, p. 71.

REGIONAL GEOLOGIC ATTRIBUTES

Tectonostratigraphic setting: Deposit is hosted by brecciated metamorphosed silicic volcanic and granitic gneiss that now contain an amphibolite facies mineralogy. Igneous protoliths once composed a continental margin magmatic arc. Brecciation and fracturing of the gneiss is unrelated to regional metamorphism.

Regional depositional environment: Gold deposition was associated with intense dilatant fracturing, brecciation, and faulting in the gneiss. The gneiss block containing the orebodies is bounded by strike-slip faults.

Age range: A Tertiary age is indicated, but an older late Mesozoic history may have been important.

LOCAL GEOLOGIC ATTRIBUTES

Host rocks: Amphibolite facies metamorphosed silicic volcanic, derivative volcaniclastic, and granitic rocks.

Associated rocks: None

Ore and gangue mineralogy: Free gold or electrum are the primary ore minerals. In the unoxidixed zones, gold is associated with pyrite. Minor sulfides include molybdenite, chalcopyrite, galena, pyrrhotite, and rare sulphosalts and tellurides. Gange minerals includes quartz, dolomite or ankerite, white mica, and minor adularia along with the metamorphic minerals quartz, microcline, plagioclase, biotite, hornblende, epidote, and sphene.

Wall rock alteration: Alteration is extremely variable. Ore grade rocks range from fractured but otherwise fresh gneiss to thoroughly bleached rock. Alteration consists of sericitization of ferromagnesian minerals and weak to moderate replacement of plagioclase by white mica and carbonate minerals.

Structural setting: Epithermal structures are steeply dipping and at high angles to subhorizontal gneiss units. The mineralized structures are subparallel to faults of normal displacement. Strike-slip faults bound the host gneiss and are at moderate angles to the mineralized veins.

Dimensions of ore in typical deposits: Unknown

Dimensions of alteration or distinctive halos: Unknown

Effect of weathering: Deep oxidization has caused some redistribution of gold.

Effect of metamorphism: The concentration of gold during regional metamorphism was probably important in the early history of the deposit.

Geochemical signatures: Au-Ag-As-Sb-Hg-W-Cu-Pb-Zn.

Fluid inclusions: Fluid inclusions are liquid- and vapor-rich with homogenization temperatures between 215 to 230° C. Fluids were dilute and boiling.

Geophysical signatures: None is known.

Ore controls/exploration guides: Insufficient data is known about these deposits to present concrete exploration criteria. Environments where gneiss-hosted kyanite gold deposits or structurally-stacked metavolcanic and metaplutonic gneiss are affected by a younger brittle deformation along high angle structures appear to be favorable. Strike slip fault systems may be important.