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PRINTED: 03/16/2004

ARIZONA DEPARTMENT OF MINES AND MINERAL RESOURCES AZMILS DATA

PRIMARY NAME: RESOLUTION COPPER

ALTERNATE NAMES:
MAGMA PORPHYRY

PINAL COUNTY MILS NUMBER: 772

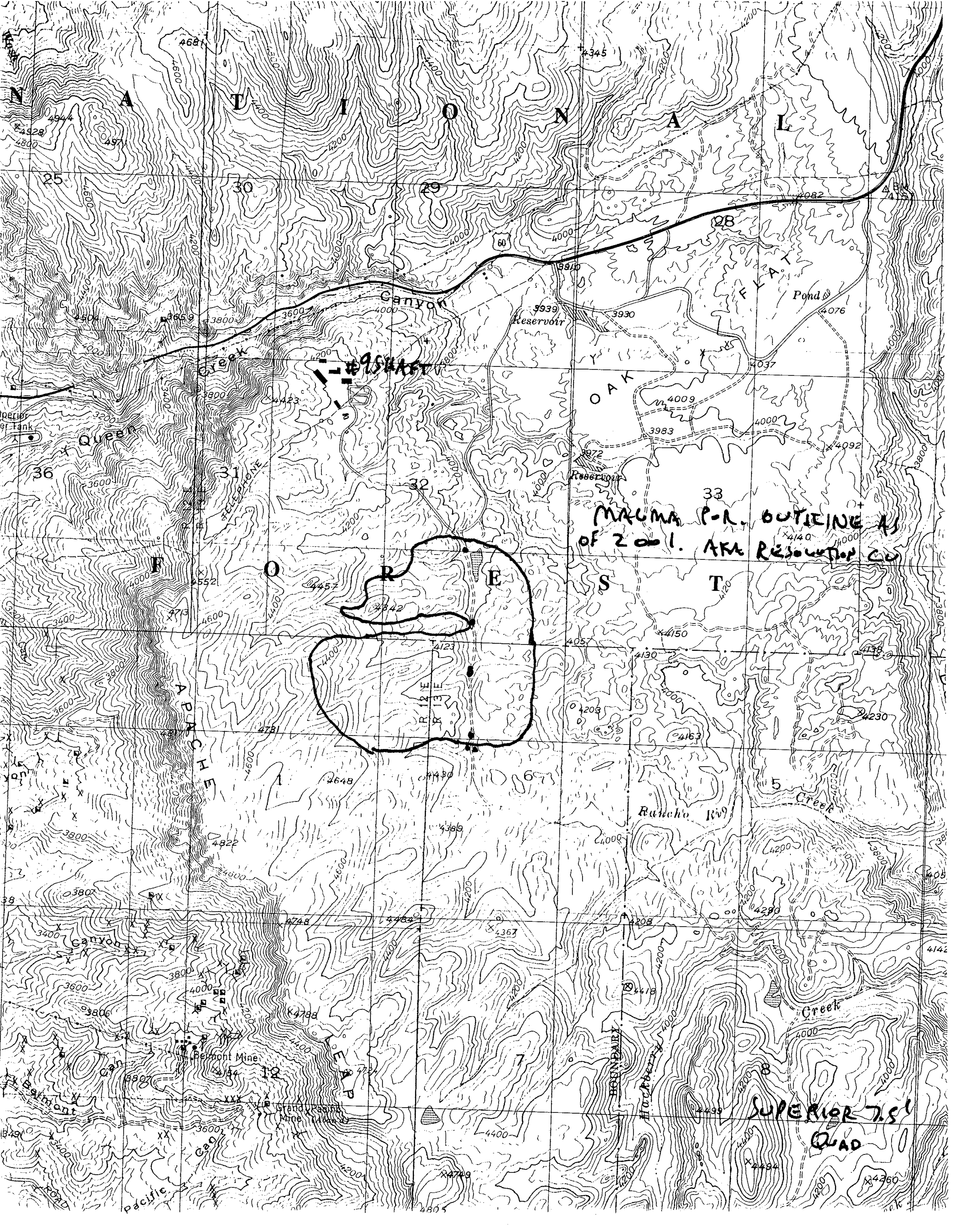
LOCATION: TOWNSHIP 2 S RANGE 13 E SECTION 6 QUARTER NW
LATITUDE: N 33DEG 17MIN 15SEC LONGITUDE: W 111DEG 03MIN 10SEC
TOPO MAP NAME: SUPERIOR 7.5 MIN

CURRENT STATUS: EXP PROSPECT

COMMODITY:
COPPER SULFIDE
MOLYBDENUM SULFIDE

BIBLIOGRAPHY:
ADMMR RESOLUTION COPPER FILE
ECONOMIC GEO. VOL 97, NO. 2, P. 197, 2002
GEOLOGY OF A MAJOR NEW PORPHYRY COPPER . . .
BY MANSKE, S.
ALSO IN T2S R12E S. 1 AND T1S R13E S.32

ALSO POWERPOINT ON FILE ON CD-ROM IN GMR CAB. DRAWER



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MAGMA P-R. OUTLINE AS OF 2001. AKA RESOLUTION CU
SUPERIOR 7.5' QUAD

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Press release

Resolution Copper Mining LLC reports an Inferred Resource of over 1 billion tonnes at its property in Arizona, USA

29 May 2008

Resolution Copper Mining LLC (RCML) has completed sufficient drilling on its deep porphyry copper deposit to report an Inferred Resource of 1.34 billion tonnes containing 1.51 per cent copper and 0.040 per cent molybdenum.

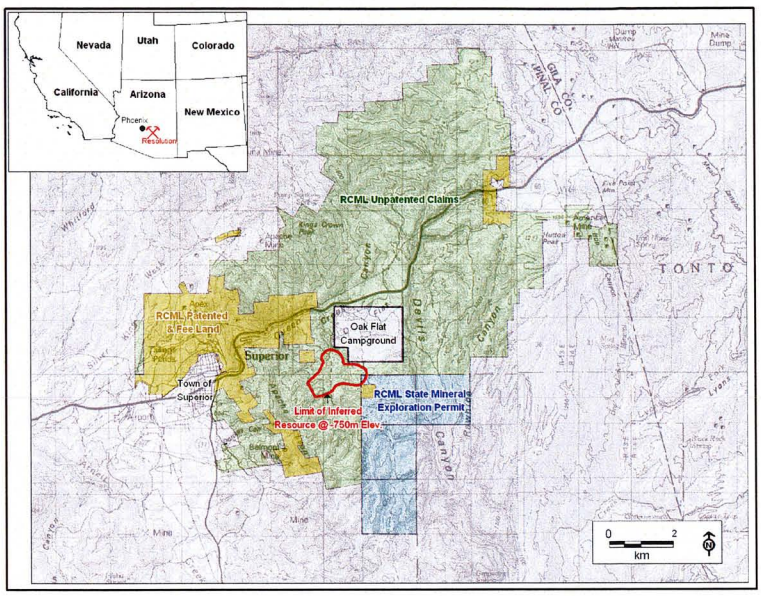
Rio Tinto Copper Group chief executive Bret Clayton said the results show that through its investment in Resolution, Rio Tinto has access to a next generation, tier one deposit. "We are confident that this asset has further potential and these early results are very encouraging. With pre-feasibility on target for 2012 and production due to commence in 2020 this is a long term, world class deposit that will support our growth well into the future."

Deposit Location

The Resolution Project, located three miles east of Superior, Arizona, USA, was originally discovered by Magma Copper Co. and BHP Billiton via underground and surface drilling conducted from 1994 to 1998. Exploration conducted by Kennecott Exploration Co. from 2001 to 2003 confirmed a large body of copper mineralization at a depth of more than 1300m below surface. Resolution Copper Company (RCC), a wholly owned subsidiary of Rio Tinto, became manager of the project in May 2004, and resumed surface drilling in 2005. Resolution Copper Mining LLC (RCML), which holds 100 per cent of the assets and liabilities of the project, is owned 55 per cent by Resolution Copper Company and 45 per cent by BHP Copper Inc. Exploration drilling and other technical studies continue in support of a Prefeasibility Study scheduled for completion in 2012.

Cont.../

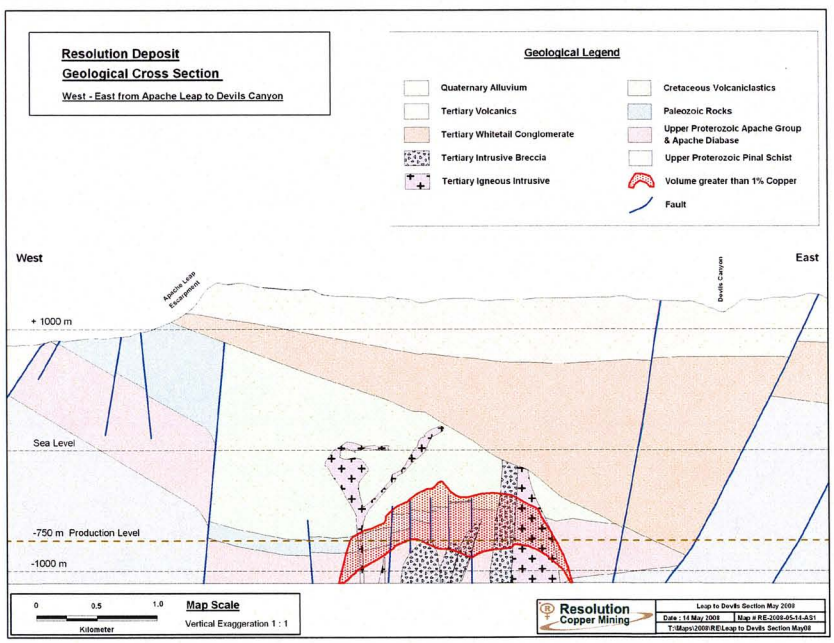
Location Map



Resolution Deposit Geology

The Resolution deposit is a world-class porphyry Cu-Mo system located beneath a minimum of 1000m of post-mineral cover. The deposit is hosted in a sequence of sedimentary and intrusive rocks varying in age from Precambrian to early-Tertiary. It is strongly host-rock controlled with the best grades typically found in strongly altered and mineralized Precambrian diabase and limestone. Several faults with >200m displacement are present within the area of the deposit, but the bulk of movement was apparently pre-mineral and does not appear to offset mineralization.

Generalized east-west cross section through Resolution Deposit



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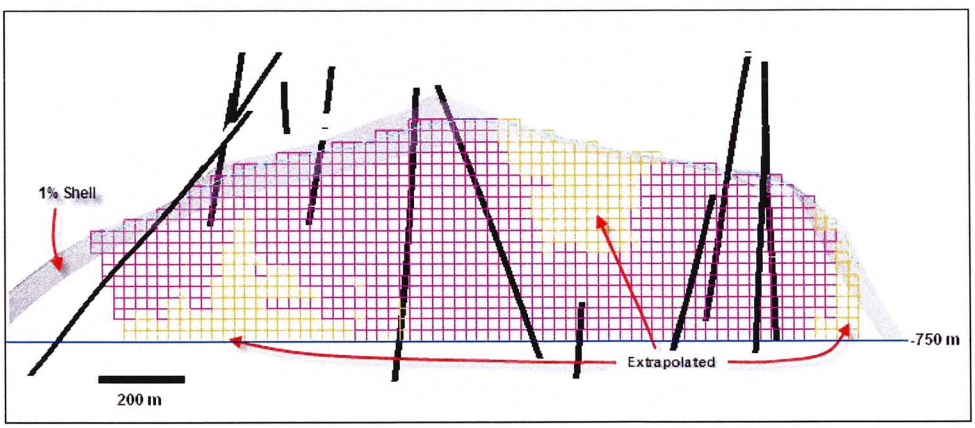
Although its ultimate size has not been fully defined, the deposit, characterized by consistent +1 per cent Cu mineralization in suitable host rocks above an elevation of 750m below sea level, extends over an area of at least 2km in an east-northeast direction and 1.5km in a north-northwest direction. Its thickness is locally greater than 500m. Significant but lower-grade mineralization extends beyond this defined body of strong mineralization.

Mineral Resource

The Inferred Resource defined at Resolution complies with the JORC Code guidelines. It is a portion of the mineralized body defined within a nominal envelope grading +1 per cent Cu constrained by a minimum thickness of 150m above -750m elevation in order to be amenable to block cave mining. Its western extent is limited by geotechnical constraints in order to protect Apache Leap, a prominent geographical feature above the town of Superior. Furthermore, the Resource is confined to an area of the deposit within which the drill hole spacing is less than 300m. For purposes of this declaration, that portion of the Inferred Resource with drill hole spacing wider than 200m, even where internal to the drill pattern, is generally considered Extrapolated Inferred. As shown in the cross section below, the majority of Extrapolated Inferred Resource is located relatively shallow in the deposit where drilling geometry has made testing difficult, and in other areas where drilling density is low.

East-northeast cross section looking north through deposit showing 25m blocks used for grade estimation identified as either Interpolated (purple) or Extrapolated (yellow)



The defined Resource includes all material contained within the constrained body of mineralization and includes weak mineralization in the core of the deposit above the -750m elevation. All dilution is internal and included in the Resource as presented.

Resource Category	Tonnes (Mt)	Cu Grade (%)	Mo Grade (%)
Interpolated Inferred	1,109	1.52	0.040
Extrapolated Inferred	232	1.47	0.044
Total Inferred	**1,341**	**1.51**	**0.040**

Within nominal +1% Cu envelope at 0% cutoff

The Resource is on ground controlled by RCML via unpatented lode claims and a State Exploration Permit. However, the Oak Flat Campground, located immediately to the northeast is withdrawn from mineral entry by a 1955 Presidential order. This property is a component of a proposed federal legislative land exchange pending before the U.S. Congress. Completion of the Land Exchange is critical to the project because without

Cont.../

this property the Resource could be compromised. Recent indications from working closely with Congressional members and their staffs place the bill on a track for a Senate hearing and action during the second half of 2008.

The most recent economic model completed in March 2008 utilizes 2007 and 2008 capital and operating cost estimates derived from ongoing pre-feasibility studies. The economics of the project support its classification as an Inferred Resource. The Base-Case mine plan includes use of the nearby Pinto Valley mine facility for milling and in-pit tailings storage. Although Pinto Valley is owned and operated by BHP Billiton (one of the owners of RCML), an agreement is necessary to allow for use of this facility as conceived.

External Review

The sampling, assaying, database management, geological interpretations, copper and molybdenum grade interpolation and summarization of the Inferred Resource has been reviewed and approved by Dr. Harry Parker, Technical Director of AMEC E&C Services Inc. and other AMEC staff under his supervision, as compliant with the 2004 JORC Code in the form and context in which it appears. Dr. Parker is a Registered Geologist in the State of Arizona and a Fellow of the Australasian Institute of Mining and Metallurgy. Dr. Parker has consented to reference of the results of this review in this press release.

CP Statement

The information in this press release that relates to Resources is based on information compiled by Carl Hehnke, who is a member of the Australasian Institute of Mining and Metallurgy. Mr. Hehnke is a full-time employee of Resolution Copper Company and has experience which is relevant to the style of mineralization and type of deposit under consideration and is qualified as a Competent Person as defined in the 2004 Edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves. Carl Hehnke consents to the inclusion in this press release of the matters based on his information in the form and context in which it appears.

The information presented here contains details of mineralization that has a reasonable prospect of being economically extracted in the foreseeable future but which is not yet classified as Proved or Probable Reserves. This material is defined as Resources under the JORC Code. Estimates of such material are based largely on geological information with only preliminary consideration of mining, economic and other factors. While in the judgment of the Competent Person there are reasonable expectations that all or part of the Resources will eventually become Proved or Probable Reserves, there is no guarantee that this will occur as the result depends on further technical and economic studies and prevailing economic conditions in the future.

About Rio Tinto

Rio Tinto is a leading international mining group headquartered in the UK, combining Rio Tinto plc, a London and NYSE listed company, and Rio Tinto Limited, which is listed on the Australian Securities Exchange.

Rio Tinto's business is finding, mining, and processing mineral resources. Major products are aluminium, copper, diamonds, energy (coal and uranium), gold, industrial minerals (borax, titanium dioxide, salt, talc) and iron ore. Activities span the world but are strongly represented in Australia and North America with significant businesses in South America, Asia, Europe and southern Africa.

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Forward-Looking Statements

This announcement includes "forward-looking statements" within the meaning of Section 27A of the Securities Act of 1933, as amended, and Section 21E of the Securities Exchange Act of 1934, as amended. All statements other than statements of historical facts included in this announcement, including, without limitation, those regarding Rio Tinto's financial position, business strategy, plans and objectives of management for future operations (including development plans and objectives relating to Rio Tinto's products, production forecasts and reserve and resource positions), are forward-looking statements. Such forward-looking statements involve known and unknown risks, uncertainties and other factors which may cause the actual results, performance or achievements of Rio Tinto, or industry results, to be materially different from any future results, performance or achievements expressed or implied by such forward-looking statements.

Such forward-looking statements are based on numerous assumptions regarding Rio Tinto's present and future business strategies and the environment in which Rio Tinto will operate in the future. Among the important factors that could cause Rio Tinto's actual results, performance or achievements to differ materially from those in the forward-looking statements include, among others, levels of actual production during any period, levels of demand and market prices, the ability to produce and transport products profitably, the impact of foreign currency exchange rates on market prices and operating costs, operational problems, political uncertainty and economic conditions in relevant areas of the world, the actions of competitors, activities by governmental authorities such as changes in taxation or regulation and such other risk factors identified in Rio Tinto's most recent Annual Report on Form 20-F filed with the United States Securities and Exchange Commission (the "SEC") or Form 6-Ks furnished to the SEC. Forward-looking statements should, therefore, be construed in light of such risk factors and undue reliance should not be placed on forward-looking statements. These forward-looking statements speak only as of the date of this announcement. Rio Tinto expressly disclaims any obligation or undertaking (except as required by applicable law, the City Code on Takeovers and Mergers (the "Takeover Code"), the UK Listing Rules, the Disclosure and Transparency Rules of the Financial Services Authority and the Listing Rules of the Australian Securities Exchange) to release publicly any updates or revisions to any forward-looking statement contained herein to reflect any change in Rio Tinto's expectations with regard thereto or any change in events, conditions or circumstances on which any such statement is based.

Nothing in this announcement should be interpreted to mean that future earnings per share of Rio Tinto plc or Rio Tinto Limited will necessarily match or exceed its historical published earnings per share.

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High resolution photographs available at: www.newscast.co.uk

Resolution Project Update Jan 2009:

Mine Shaft Construction Progressing on Two Major Fronts

As 2009 begins, we are moving forward with shaft construction on the new #10 mine shaft. Three major Resolution Copper contracting partners, Cementation, Sundt Construction, Inc. and Schuff Steel Company are involved in this work, and 200 to 250 contract workers will be on-site to complete project milestones over the next three months. Two major construction projects are underway simultaneously on the shaft. First, active shaft sinking using a temporary sinking setup began in late December 2008. To date, the shaft has progressed to a depth of 260 feet. At the same time, we're constructing a permanent setup for the hoist and headframe to be completed by July. Sundt Construction, one of the largest contractors in Arizona, is leading the surface foundation work.

Shaft-Sinking Technique

Until the permanent setup is complete, we are using what's known as a "slashing" technique to extend the shaft down to the level of the previous Never Sweat tunnel. This entails drilling and blasting rock to extend the size of the shaft from the current 7-foot raise bore to a 30-foot excavated diameter, then allowing the rock to fall to the previous 1,100-foot (Never Sweat) level. As shaft expansion is completed, a concrete lining is installed to a fi nished diameter of 28 feet. When the permanent headframe and hoist are in place, we will transition to traditional shaft sinking, which involves blasting rock to reach a greater depth, then hoisting the rock up to the Never Sweat level where it will be hauled by rail tunnel to the west plant and used for reclamation.

Raising the Headframe – Major Milestone

Erecting the permanent headframe is a major effort and will be led by expert steel fabricator/contractor, Schuff Steel Company. A Phoenix-based company, Schuff has a long history in Arizona mining and, in fact, built the #9 shaft headframe 38 years ago. This company is also well known for other high-visibility construction efforts, including completion of the Bank One Ballpark and the University of Phoenix Stadium. Other contracting partners involved in our mine construction efforts include Cementation, who is in charge of underground shaft-sinking efforts; DalMolin Excavating, who aid us in a variety of ways, including excavation and road construction and maintenance, Marcanti Electric, Inc., who manage necessary electrical work, and Albo Guzman Trucking, who assist in hauling rock from shaft development.

Excerpt from: Resolution Copper Mining (RCM) *Issues Brief January 2009*

NJN

Resolution Copper (A)
12/2005

RIO (A$62.99)

Ø The market has yet to get its mind around the Resolution Copper Project.

Ø Maybe it will help to think of it as the revenue equivalent of a 4 billion barrel oil discovery or a 300 million ounce gold discovery.

Tom Albanese, CEO Rio Tinto Copper presented to analysts this morning - RIO is surprised at how well molybdenum has held up (we expect it to fall from US$32/lb to US$17.0/lb in CY'06) and if it continues to maintain current prices of US$32/lb then they will look to maintain volumes at CY'05 levels – whereas current planning is for a 10% decline in volume. We may have to trim CY'07 profit estimates marginally as current plans indicate RIO is unlikely to be entitled to any Grasberg copper sales by virtue of the low copper grade scheduled for CY'07. RIO is tempted to build a nickel business around its Eagle and La Sampala properties and is in no way looking to sell its 40% interest in the Cortez Gold Project – discovery upside is too high.

In our view, however, the most significant asset in RIO's copper portfolio at present is the Resolution Copper Project in Arizona – 55% RIO and 45% BHP and we were interested in any comments on this project.

Rio Tinto comments on the Resolution Copper Project

Ø Large and high grade.

Ø Current focus on establishing the size of the ore envelope.

Ø Despite its depth and high temperatures this is a very attractive project because of its high grade.

Ø In 2006 two shafts will be sunk; the first an extension of the existing shaft at the old Superior Mine will be deepened from 1km to 2km, the second and new shaft will be sunk to 2km as well.

Ø This will allow rock stress testing, heat control/ventilation and water studies and of course grade continuity, all with a view to completing a feasibility study sometime post 2009.

Ø Under a traditional block cave technique mine development could then take another 3-4 years. We're unlikely to be looking at a producing mine before 2014 (interestingly this may not be too far away from the expansion of BHP Billiton's 100% owned Olympic Dam project, which the market is already willing to ascribe a value).

Austock's early take on Resolution (see attachment for our views in April last year)

The size of this mineral resource is so large it defies the imagination. In the past RIO has said the mineralization is greater than 1.5 billion tonnes and the grade about 1.5% copper. This was based on the first round of 17 very deep and very expensive holes that indicated the mineralization extended for at least 1.5km by 1.5km and was 450m thick.

Resolution could have a footprint of 2.7 million square meters or almost 4 times the size of the Grasberg Main Block Cave which occupies 700,000 square meters. Until the discovery of Resolution the Grasberg block cave had been regarded as potentially the largest block cave in the world.

We gather from many sources that the grade is unusually high for a porphyry deposit. We note that the average grade of copper recovered in the district has been almost 5% copper from 25mt of ore treated and that in the last 6 year's of the Superior mine life some 2mt was mined at an average grade of 5.2% copper. We would not expect these high grades to be replicated in the porphyry, nonetheless, it could be much higher than the 1.5% indicated to date.

Rio has said that this is the highest grade discovery in North America and that the size of the resource rivals or even exceeds Escondida.

In the attached paper released by Austock in early 2004 we hypothesized that the resource could be 1.8km long east/west, by 1.5km wide north/south and 450m thick. This indicates a resource of over 3.0 billion tonnes, which at a copper grade of 1.5% indicates an in situ resource of 46 million tonnes of copper.

But the signs seem to be pointing to a grade in excess of 1.5% copper. We know that the discovery hole averaged some 1.9% copper over 47m and that high grade veins in the district have averaged over 5% for reasonably large tonnages. By way of example should the grade of the high grade zone average 2.5% copper then RIO/BHP may be the lucky owners of a resource containing 75 million tonnes of copper, if the dimensions remain 1.8km by 1.5km, or say 42 million tonnes if the dimensions of the high grade mineralization were 1.5km x 1.0km by 450m thick.
The point is that this is a very large discovery and it is still not fully defined. At a long-term copper price of US$0.90/lb it could represent some US$85-150bn in potential gross revenues or, to stretch a point, equivalent to a 3.3-5.7 billion barrel oil discovery at a long-term oil price of US$26/bbl or a gold resource of 215 – 375 million ounces.
In our view this project will eventually capture the attention of the equity market in a big way and it is clearly of the utmost importance to RIO and BHP.

Current Progress

Ø Rio spent US$25m on exploration drilling to earn its 55% equity interest around May 2004. This forms part of a five year US$200-300m pre feasibility study including the two shafts and much more underground drilling.

Ø In January 2005 the company commenced its second drill program to determine the borders, grade and distribution of the mineralization.

Ø Rio is in the midst of a 2 year program to gain some 3,200 acres of Federal land around Resolution, in a swap for 4800 acres of land over which Rio currently has entitlement but is not prospective for minerals and can be used for national parks.

Ø Rio Tinto has positioned itself at the forefront of block caving technology in order to build up core skills to take on the next generation of copper opportunities. Rio has experience from Palabora and Northparkes and is working with Freeport on block caving at Grasberg. Argyle will be developed as a block cave (in our view) and most likely so will Bingham Canyon post 2017. Resolution is deep and hot but it is a project that may eventually produce anywhere between 500,000 -1,500,000 tonnes of copper per annum from a series of shafts and parallel block caving operations.

What is it worth?

Ø It is too early to call in the absence of any meaningful information from RIO.

Ø However, in the attached paper we suggested a ball-park valuation of some US$4bn or about A$2.20 per RIO share (or 4% of the value of the company) and BHP about A$0.40/share (2.7%) assuming a copper grade of 1.5%. Grades closer to 2.5% copper could see indicative values at least 50% higher.

Ø How quickly could this be built into the share price? We don't expect any time soon. Nonetheless, this is a significant asset and can be expected to generate many billions of dollars of shareholder value. Clearly a buyer of either RIO or BHP gets this asset for free. In this regard there is no downside and indeed a lot of upside should copper supply struggle to meet demand in the long term.

Maintin buy on RIO TINO – share price target A$69.50.
BHP rated HOLD – share price target A$23.10.

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Visit to Resolution Copper (f) and Magma Mine (f) - Pinal County
Number 9 shaft area and West plant site
April 16, 2004 summary by Nyal J. Niemuth, Mining Engineer

Rio Tinto = RT

Meeting with Resolution Copper personnel Bruno Hegner, Vice President General Mgr., Jennifer Russo, Corporate Communication Director, Carl Hehnke, Site Manager. Also attending was Richard Ducote of the Arizona Daily Star (Tucson) newspaper.

Rio Tinto negotiated for a couple of years for the option to earn a 55% interest in the entire Superior Magma mine including the Resolution Copper property. RT has now spent the $25 million to earn a 55% interest. RT takes over the property (everything known as "Magma Superior") May 1, 2004. After that date BHP-Billiton has to put up 45% of what RT spends or have their ownership interest reduced/diluted. RT has hired Montgomery and Assoc. to develop a regional hydrogeologic model for the mine area. Baseline environmental studies are also being done. There are no endangered species known in the area. Further exploration is needed before a reserve number can be applied to the discovery. Oscar Groeneveld, chief Executive of RT, made the resource comment in Australia to a financial analyst that was reported in the Northern Miner's January 2004 article.
RT reported no interest in purchasing the nearby Superior East deposit from Asarco. They don't believe it has the grade or continuity to warrant development. More exploration might show that it is related to Resolution Copper.

Exploration

Prior work was horizontal holes from the underground. Deepest underground workings are near sea level. Magma had problems completing those holes due to fault zones and pressure. Bruno Hegner arrived at project April 17, 2001. Carl Hehnke is site manager. July 2001 RT started a surface drill exploration program. Drilling recovered 10 miles of HQ core from 17 holes at a cost of approximately $500,000 per hole. Initially drill rigs occupied 4 existing sites, later RT developed a 5th site about 1500(?) feet to the east. Holes were initially drilled with a rotary rig to a depth of about 3,000'. Drilling HQ core down the hole another 3-4,000' followed this. From the first completed hole they then drilled deflection holes using wedges and a directional drill motor that is driven by pumping drilling mud fluids thru it. It can direct a hole 3 degrees per 100' drilled.
Hundreds of feet of drill core including mineralized intercepts were displayed along with sample boards identifying the local geologic column's lithology, as well as samples showing the deposits alteration, mineralization, etc. The logging geologists used these for consistency in identification. We were told about the chain of custody procedures used during sample splitting and storage prior to shipment for assay. In addition, the split core has been digitally photographed with copies archived off site. A lot of structural information was also logged prior to splitting and can often also be seen in the split drill core photographs.

No resource has been formally announced. More drilling needs to be done to define the deposit's limits and content. The US Securities and Exchange Commission would not approve 300 meter drill spacing for reserves. The bottom of deposit is not well known, but is generally estimated to be about 750 meters below sea level. That would be the depth of a new level if one is developed. The existing number 9 shaft is 3,600' deep (about sea level) and about 4,200' total depth to the sump. The mine is officially on "care and maintenance." The number 9 shaft's skip is lowered down to 500 level once a month where the fresh water pumps are for the cooler and potable use. MSHA inspects the mine once a month.

Three technical hurdles must be overcome to develop the mine: depth, heat (23 degrees per 1000 meters) and rock stress. Macintosh Engineering has been contractor on site for this project. RT is concerned it would need to use French Canadian contractors to deepen the shaft and drive a drift and they doubt Homeland Security would issue so many foreign French-Canadians explosive permits. Big mines need big openings for large equipment. These are more difficult at great depth due to the danger of rock bursts.

RT plans to model community relations and sustainable development at Superior after the Palabora Foundation in Africa. Jennifer Russo is doing most of community work. They believe they have 100% support of Superior community. RT is developing education and community programs, see www.resolutioncopper.com for more details.

Excerpt from: http://www.amverco.com/Foundation.htm
In all its work, the Foundation takes a long term view of community development and strives in partnership with communities, to encourage the growth of the following:
A significant pool of technically skilled, educated and literate people.
An efficient community management structure.
Community pride and loyalty.

Leaders who epitomize these qualities, who are able to lead and manage wisely and are committed to the welfare of their people.

Our main fields of service are Education, Technical Training, Small Business Development, and General Community Development.
The Foundation's financial support is derived mainly from its sponsor, the Palabora Mining Company, which contributes 3% of its after-tax profit on a annual basis.

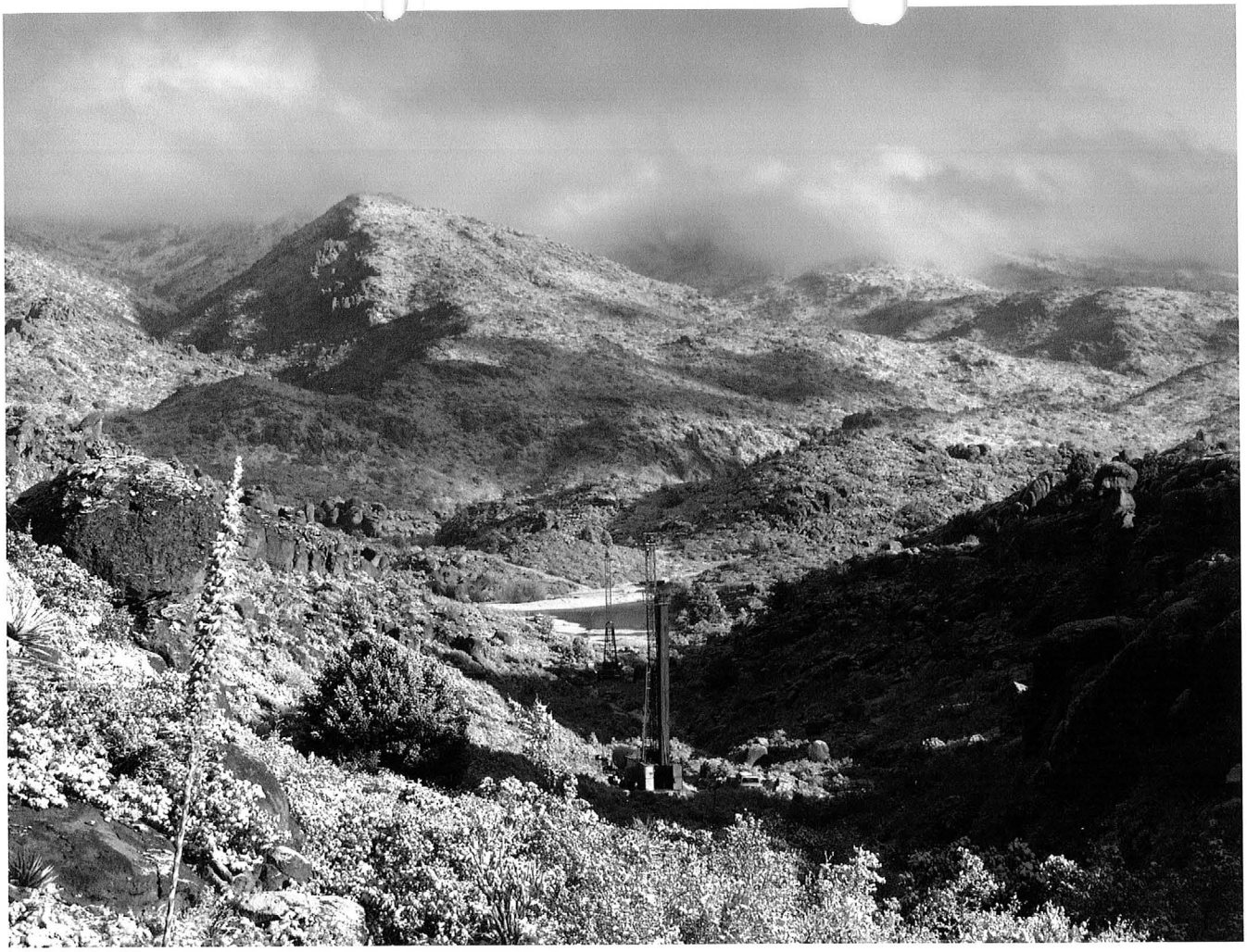
Resolution Copper company has noted the permitting difficulties of some Canadian companies who have attempted to develop mines in Arizona and hope/believe they can avoid those mistakes. They have long run support of RT for the project and community.
RT has had good support from elected officials at all levels of government. Project won't go forward until "multiple use issues" on Forest Service lands are taken care. RT plans a "Apache Leap Dacite" protection plan for some of the private land, perhaps some kind of preservation trust to show commitment to environment and community. Other area of concern is the Devils Wash riparian habitat that exists on state lands. RT will understand that better when the hydrogeologic model is complete. The mine surface projection sits between those two areas.

West Plant Site
The mill, smelter, and tailings site at Superior will be known as the "West Plant Site." RT plans to cover the 13 million tons of tailings with an anaerobic cover. Various "cover" ideas and materials are being investigated. About half this material is the undersize from the sand fill. It is unknown when it will oxidize but it will at some time. RT plans to add additional storm water capacity for the tailings and plant site to accommodate the 100-year storm event. RT plans to work with University of Arizona's Arid Lands Studies group on this and other issues. RT has identified 225 mine openings in the Queen Creek Canyon area and plans to close the worst 90% of them. $2 million has been allocated for work on those matters and will begin soon after their takeover May 1, 2004. RT reports there is a stockpile of pyrite left over from the previous sales program to Coors (iron for brown beer bottle glass) and would be willing to sell that material.

Drilling at the existing 4 pad sites impacted only 1.5 new acres. The drilling rigs used "baker tanks" to contain drill muds that were then disposed of in a landfill. RT will plan any development using the "brownfield sites" leaving the as much of the rest of the site in its natural state. The project site has lots of existing infrastructure: 56kv(?) power line running thru project, US highway, existing access roads, Neversweat haulage tunnel to the West plant site, etc.

Miscellaneous
The surface of the deposit is Forest Service land. The mineral rights are held by mining claims staked in 1917(?). The claims were resurveyed 2 years ago and 77% of the old 4x4 corners were found. Also found 24 gaps or fractions. RT has fixed those of course and put up new monuments.

Teck-Cominco is exploring in area. Mr. Hegner wonders how they can find targets as geophysics and geochemistry won't work. Magma geologists following up alteration seen in underground drill holes discovered Resolution Copper. A large exploration budget is required for such deep and expensive holes.



MACMA PORPHYRY (P)

Arizona Corporation Commission
State of Arizona Public Access System

06/11/2002 11:06 AM

Pending File Inquiry

File Number: N10327481 Reservation Number: 45712
Corporation Name: RESOLUTION COPPER COMPANY RIO TINTO SUBSIDIARY

Designation Type: N NAME RESERVATION
Pending Type Code: R NAME RESERVATION
Location Code: P PHOENIX
Date Received: 05/31/02 Date Returned: ?
Approval Date: ?
Reason Returned: BLANK
Corp Type: User ID: THERESAT
Expedited Date: 05/31/02 Expiration Date: 09/29/02

Contact: CORPORATION SERVICE COMPANY
Address: SHANNON MCKNIGHT
818 E OSBORN RD STE 214
PHOENIX, AZ 85014
Comments:
Comments:

- **Return to STARPAS Main Menu**
- **Return to A.C.C. Corporations Division Main Page**
- **Return to Arizona Corporation Commission Home Page**

(2) [illegible]

ARIZONA No. 38 June, 2004

Mineral Resource

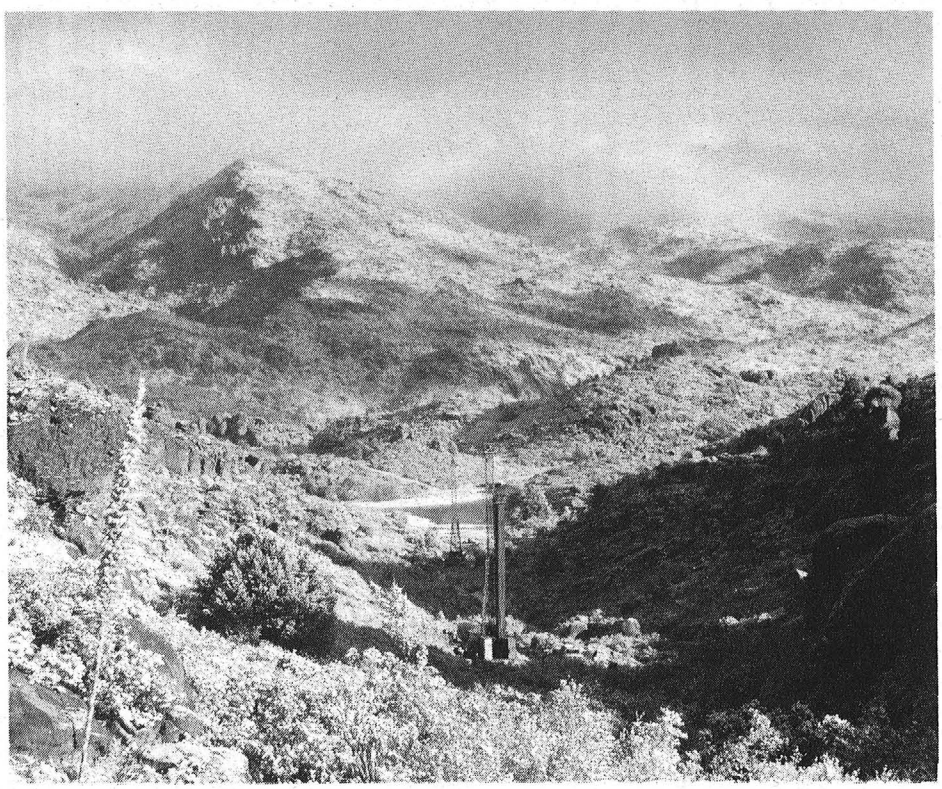
Resolution Copper Takes Over

A porphyry copper deposit discovered near Superior has the copper-mining industry excited – an industry that has had little to cheer about for the past 6 years. Now, along with copper prices being close to record-high levels, there is the Resolution Copper deposit. It is difficult to decide what is the most remarkable aspect of this discovery. That it is huge? It may be the largest copper deposit in North America. Although resources have not yet been fully defined, it is estimated to contain at least a billion tons. That it is deep? It lies about 1000 feet below sea level and 7,000 feet below the surface. That it is high-grade? The deposit has mineralization of 1.5 percent copper, two or more times the grade of ore typically mined here. Or is it the nature of this deposit that is most amazing? The presence of this huge, high-grade deposit, underlying the Magma mine has implications for the other copper mines in the Southwest and has mining companies wondering what lies beneath *their* deposits.

The deposit, deeply buried under post-mineral rocks, was first intersected by drill holes from the underground workings of the Magma mine in 1995 by Magma Copper. In July 2001 Kennecott Exploration started a surface drill exploration program southeast of the #9 shaft. Drilling recovered 10 miles of HQ core from 17 holes at a cost of $500,000 per hole. Initially, drill rigs occupied four existing sites. Kennecott Exploration later developed a fifth site further to the east. Holes were initially drilled with a rotary rig to a depth of 3,000 feet. This was followed by drilling core holes another 3,000 to 4,000 feet. From each initial drill hole deflection holes were then drilled using wedges and a directional drill.

Before releasing reserve figures, more drilling needs to be done to define the deposit's limits and copper content. The bottom of the deposit is not totally know, but is estimated to be generally about 2500 feet below sea level.

Three technical problems will need to be overcome to develop the mine: depth, heat, and rock stress. Mining at 6,500 feet means local rock temperatures of up to 170 degrees F. Rock stress at that depth is obviously going to be a concern. No mining method has been selected. Before these matters can be addressed Resolution Copper Company, Kennecott Exploration's successor in interest, must deal with surface multiple-use concerns, complete the regional ground water study being conducted by Montgomery and Associates, and continue gathering baseline data.



Arizona Department of Mines & Mineral Resources, *1502 W. Washington, Phoenix, AZ 85007*
602-255-3791, toll-free in Arizona 1-800-446-4259, www.admmr.state.az.us

London-based Rio Tinto earned a 55 percent controlling interest in the property from BHP-Billiton by spending $25 million on exploration. The resulting joint venture company, Resolution Copper Company, took over management of the project, which includes the Superior underground mine, concentrator, and smelter, on May 1 of this year. Initial exploration was completed in February of 2003. Resolution plans to continue evaluation for the next three years. They will also undertake two voluntary remediation projects at the existing mine site. Many of the adits, tunnels, and other workings in Queen Creek from previous mining operations will be closed or gated to retain their function as habitats for bats, snakes and other wildlife. Also, stormwater retention capabilities on the West Plant Site near Superior are being expanded. The existing tailings are being studied to see how they can be sealed. The company has set aside over $2 million for these projects in 2004.

Development of the project could easily exceed $1 billion, and although it is too soon for firm target dates, construction could begin sometime after 2010. The mine could generate nearly 1,000 construction jobs and 400 permanent, high-paying mine jobs. The deposit, once developed, would produce for an expected lifespan of 25 years.

Meanwhile, the company is working on solidifying community support for the project. Resolution holds open house festivities, awards scholarships, supports the Boyce Thompson Arboretum, participates in local mining competitions, and hosts ice cream socials. If and when the Resolution Copper mine becomes a reality, Resolution Copper Company and the town of Superior will be ready.

Geology of the Resolution Deposit

The following excerpts are from technical papers on the geology of the Resolution deposit. Citations are provided.

"The upper kilometer of the deposit, pervasively sericitized and with abundant pyrite and later bornite-chalcocite, is overprinted by advanced argillic alteration with kaolinite, dickite, and less alunite, topaz, pyrophyllite, and zunyite. The vein-controlled, high sulfidation assemblage pyrite + chalcocite correlates most strongly with advanced argillic alteration and copper grades greater than 10%. Deposits sharing features seen in the upper portions of the Magma porphyry include some of the world's largest copper deposits (e.g. Butte and Chuquicamata). The discovery of this style of porphyry ore in the southwestern US should serve as an incentive for renewed exploration efforts there."

Sandra Troutman, *Advanced argillic alteration in the deeply buried Magma Porphyry Cu-Mo prospect, Superior, Arizona*, Abstract from SME Meeting, 2002

"Surface and underground drilling into the deposit has outlined a zone of >1.0 percent hypogene Cu that is at least 750m long by 250m wide by 300m high, elongated to the eastnortheast. The same volume of rock also averages 0.02 percent MO and 2 ppm Ag. The zone apexes approximately 300m below sea level, slight more than 1.5 km below the ground surface, and remains open in all directions laterally and at depth. Four of the last five drill holes penetrating this zone ended in rock assaying >2.0 percent Cu."

Scott Manske and Alex Paul, *Geology of a Major New Porphyry Copper Center in the Superior (Pioneer) District, Arizona, in Economic Geology*, Vol. 97, March-April 2002.

ADMMR's Historical Photograph Collection

Since the time that the Department came into existence in 1940 the staff has been taking photographs of Arizona mines and adding them to their field reports. The Department also accepted donation of photographs from mining companies and individuals. The collection grew.

In 1996, volunteer Keith Halsey began the formidable task of cataloging the collection. He logged more than 100 hours per winter season for the next three years, determining the date of the photographs, labeling them, and entering the data. In addition, he made a photocopy catalog of the collection to relieve use on the original photos by the public.

Currently there are nearly 2,000 photos, and negatives cataloged. They represent 375 mines and other sites. As there are over 10,000 sites in the Department's AzMILS database, this means that most mine sites are not represented. Approxi-

Resolution Copper (H
Magma Mine & Pinal

Contact
Jennifer Russo, 602.956.0223, ext. 15
Corporate Communications Director

Resolution Copper Company

NEWS RELEASE

Resolution Copper Transitions to Managers of Resolution Project; Commencement Celebration Set for May 18

SUPERIOR, Ariz. — Resolution Copper announced today its official transition to manager of the Resolution project, a joint venture between Resolution Copper Company and BHP-Billiton. The company takes the helm after crossing the $25 million mark.

"This project will have significant direct and indirect economic benefits for Superior throughout the operational life of the mine," said Bruno Hegner, vice president and general manager of Resolution Copper. "This transition will allow us to further our partnership with the residents of the Town of Superior and continue to identify mutually beneficial ways that we can work together on issues of concern."

Resolution Copper will continue further environmental and geotechnical evaluations of the property. During the remainder of 2004, the company will undertake two voluntary remediation projects at an investment of nearly $2million dollars. One of those projects will involve closing adits, tunnels and other workings that remain from previous mining operations. The second initiative will focus on improvement of housekeeping and stormwater retention capabilities on the West Plant Site near town.

To commemorate the transition to manager of the Resolution project, the company will host an ice cream social on Tuesday, May 18, from 4:30 –6:30 p.m. to dedicate their new office at the West Plant Site. Guests will enjoy live entertainment from local favorite Sipie and His Big Band Sound. Treats will include delicious ice cream, plus face painting and balloon sculpting for the kids. There will be a special ribbon cutting ceremony at 5 p.m. The West Plant Site office is located at 102 Magma Heights, just east of town. There is not cost to attend this event.

-###-

Abstract from SME Annual Meeting 2002

Troutman, Sandra, 2002, Advanced argillic alteration in the deeply buried Magma Porphyry Cu-Mo prospect, Superior, Arizona

The upper kilometer of the deposit, pervasively sericitized and with abundant pyrite and later bornite-chalcocite, is overprinted by advanced argillic alteration with kaolinite, dickite, and lesser alunite, topaz, pyrophyllite, and zunyite. The vein-controlled, high sulfidation assemblage pyrite + chalcocite correlates most strongly with advanced argillic alteration and copper grades greater than 10%. Deposits sharing features seen in the upper portions of the Magma porphyry include some of the world's largest copper deposits (e.g. Butte and Chuquicamata). The discovery of this style of porphyry ore in the southwestern US should serve as an incentive for renewed exploration efforts there.

Notes taken February 27, 2002 by Keith R. Long, Economist, Geologist, USGS – Tucson

This talk presents results of a thesis or dissertation by a student at Stanford University. Ms. Troutman logged more than 13,000 feet of drill core from the advanced argillic alteration zone of this deposit for this study.

Magma Porphyry is located south of replacement deposits of the Magma mine within a down-dropped structural block. Drilling of this block from the surface in the 1960s found little. Drilling in the 1990s from the southernmost portion of the underground Magma mine (workings along Second Vein) cut the porphyry deposit. An entire porphyry system has been preserved in this down-dropped block. Deepest drilling has cut low-grade copper mineralization (0.2 to 0.3 percent copper) similar to protore at other Arizona porphyry deposits. This suggests that most Arizona copper porphyries mined, which have undergone secondary enrichment yielding economic grades, may have derived much of their secondary copper from a new eroded, high-grade hypogene chalcocite zone such as that found in the Magma porphyry.

The deposit, related to Cretaceous intrusives, is strongly vein controlled with very high hypogene copper grades (1 to 2 percent copper overall). There is little secondary enrichment. Sulfide mineralogy comprises chalcocite-digenite, bornite, and pyrite. Pervasive quartz-sericite alteration is cut by a fan-shaped pattern of argillic alteration around massive sulfide veins. Advanced argillic alteration correlates highly with ore grade, which may exceed 3 percent copper. At deep levels, the quartz-sericite alteration passes into a zone of biotite alteration then into skarn. The quartz-sericite zone extends laterally into propylitic alteration. Pyrite occurs throughout the deposit.

Vein-types (mineralization stages) from oldest (1) to youngest (5) are:

Stage	Mineralogy	Usual Width	Max Width	Comments
1	quartz-molybdenite	5 to 20 mm	40 cm	
2	pyrite	2.5 to 30 mm	2.0 m	
3	bornite-chalcocite-kaolinite-alunite-pyrophyllite	10 to 20 cm	3.0 m	most of ore
4	Dickite-bornite	5 to 30 mm		
5	zunyite	5 to 10 mm		very rare

Chalcocite and alunite are both hypogene. Evidence for this is presented by the Black Beauty vein, 3 meters wide, in which chalcocite and bornite were deposited coevally. There is no enargite.

TECHNICAL PROGRAM
Tuesday PM

Effectiveness of Pennsylvania's Remining Program in Abating Abandoned Mine Drainage: Part I - Water Quality Impacts: *M. W. Smith,* Pennsylvania Dept. of Environmental Protection, Hawk Run, PA and *K. B. C. Brady,* Pennsylvania Dept. of Environmental Protection, Harrisburg, PA

The Pennsylvania Dept. of Environmental Protection has issued permits since 1984 that authorize remining in areas that will affect preexisting pollutional discharges. These permits require the mine operator to employ best management practices to reduce pollution loading from abandoned mine discharges. Over 109 completed mining operations with 236 discharges were evaluated to determine the impact to water quality. Overall, acid loading from these discharges was reduced by 7200 kg (15,900 lbs) per day or 61%. Metals loadings were also reduced. For acidity, 44% of discharges improved or were eliminated, 55% showed no significant changes, and less than 1% got worse. Loading reductions were from a combination of reduced concentrations and lower flows.

Effectiveness of Pennsylvania's Remining Program in Abating Abandoned Mine Drainage: Part 2 - Efficacy of Best Management Practices: *J. W. Hawkins,* Office of Surface Mining and Reclamation Enforcement, Pittsburgh, PA; *K. Miller,* DynCorp., Alexandria, VA; *K. B. C. Brady,* Pennsylvania Dept. of Environmental Protection, Harrisburg, PA; and *J. Cuddeback,* DynCorp., Alexandria, VA

Remining of abandoned coal mines in Pennsylvania requires the implementation of pollution abatement and mining techniques called Best Management Practices (BMPs). Water-quality data from over 100 remining sites with more than 230 abandoned discharges were analyzed with respect to the types of BMPs employed to abate the pollution loadings of acidity, iron, manganese, aluminum and sulfate. Overall, remining and reclamation were highly successful in terms of reducing pollution loads or at the very least not causing significant degradation, while gaining reclamation of abandoned mine lands without the use of Abandoned Mine Land funds.

Office of Surface Mining and National Endowment for the Arts Coal Country Initiative: *T. A. Comp,* US Dept. of Interior, Washington, DC

The Dept. of the Interior Office of Surface Mining (OSM) and the National Endowment for the Arts (NEA) initiative provides grants to non-profits to support projects involving artists, designers, scientists, and communities in creating effective and imaginative acid mine drainage (AMD) remediation project in Appalachia. The OSM and NEA program is effective in its purpose of constructing remediation systems that treat water and are aesthetically pleasing and pragmatic to communities who will ensure long-term site use and maintenance. This program inherently creates innovative partnerships with public agencies, other nonprofits, and private industry as well as new funding opportunities in its efforts to remediate AMD.

The Dark Shade Brownfields Project: Abandoned Coalfields as Brownfields: *D. C. Ciotti,* Central City Borough, Central City, PA

In Somerset County, Pennsylvania, a coalition of groups is addressing the devastating impact of pre-regulatory coal mining and industrial abandonment of the Dark Shade Creek Watershed. Dark Shade Creek is the most polluted stem of the most polluted river in Western Pennsylvania, its watershed a blighted landscape pocked by hundreds of acres of abandoned industrial sites, former mine lands boney piles, and 21 AMD discharges. Three of these discharges flow at more than a thousand gallons per minute. Through the efforts of the non-profit AMD&ART, Inc., the Borough of Central City, and the Office of Surface Mining Watershed Assistance Team, the Dark Shade Creek Watershed was the first AMD-impacted watershed recognized as a Brownfield.

2002 SME ANNUAL MEETING

GEOLOGY III: STUDENT GEOLOGISTS ADDING VALUE AT MINING PROPERTIES

2:00 PM — Flagstaff 3-4

Chair: M. W. Hitzman, Colorado School of Mines, Golden, CO

Sequence Stratigraphic Framework for the Siluro-Devonian Host Rocks, Northern Carlin Trend, Nevada - Constructing a New Framework for District-Scale Exploration: *R. A. Furley,* Colorado School of Mines, Golden, CO; *G. L. Griffin,* Barrick Goldstrike Mines, Inc., Elko, NV; and *J. D. Humphrey* and *M. W. Hitzman,* Colorado School of Mines, Golden, CO

Past depositional models for the Bootstrap Limestone, Roberts Mountains, and Popovich facies only provided static representations of the carbonate system for the northern Carlin trend based on an instant in geologic time. This study successfully used a new approach by integrating time and relative sea-level changes to track migration of facies. The sequence framework developed in this study shows that during a highstand systems tract (HST), a massive Bootstrap Limestone platform facies was deposited adjacent to the Roberts Mountains Laminated Micritic Limestone member, representing slope and basinal facies. A topographic high developed, resulting in deposition of an apron facies on the slope. The subsequent fall in relative sea level resulted in a sequence boundary and deposition of the overlying lowstand systems tract (LST) Popovich Wispy basinal facies. The overlying Popovich Planar facies signifies another change in relative sea level and the beginning of the trangressive systems tract (TST).

Significance of Multiple Hydrothermal Carbonate Alteration Events at George Fisher Mine for Exploration of Mount Isa-Style Zn-Pb-Ag and Cu: *L. H. Chapman,* Colorado School of Mines, Golden, CO

George Fisher mine (107Mt@ 93g/t Ag, 5.4% Pb and 11.1% Zn) is the northernmost site of Mount Isa-style Zn-Pb-Ag hosted by the ubiquitously fine-grained, carbonate-rich Proterozoic Urquhart Shale. Geochemical and temporal zonation of carbonate mineral phases at George Fisher is a product of partial superposition of syntectonic Cu mineralization on syndiagenetic Zn-Pb-Ag mineralization. Hydrothermal dolomite-ferroan dolomite-ankerite and calcite alteration formed during early burial diagenesis prior to Zn-Pb-Ag mineralization, and are major rock forming constituents of the Urquhart Shale at George Fisher. These carbonates are distinguished by unique stable isotope geochemistry and are enriched in $(Fe,Mn)CO_3$ relative to paragenetically equivalent carbonates distal to sites of economic Zn-Pb-Ag. Syntectonic ferroan dolomite-ankerite-ferroan ankerite alteration is pervasive throughout the deposit hanging wall and occurs with subeconomic Cu mineralization.

MACRO PORPHYRY CU/ PINAL

Advanced Argillic Alteration in the Deeply Buried Magma Porphyry Cu-Mo Prospect, Superior, Arizona: *S. M. Troutman,* Stanford Univ., Stanford, CA

The upper kilometer of the deposit, pervasively sericitized and with abundant pyrite and later bornite-chalcocite, is overprinted by advanced argillic alteration with kaolinite, dickite, and lesser alunite, topaz, pyrophyllite, and zunyite. The vein-controlled, high sulfidation assemblage pyrite + chalcocite correlates most strongly with advanced argillic alteration and copper grades greater than 10%. Deposits sharing features seen in the upper portions of the Magma porphyry include some of the world's largest copper deposits (e.g., Butte and Chiquicamata). The discovery of this style of porphyry ore in the southwestern US should serve as an incentive for renewed exploration efforts there.

What Dikes Tell Us About the Paleo-Environment: An Example from the Carlin Trend, Nevada: *M. W. Ressel,* Newmont Mining Corp., Valmy, NV and *W. Dunbar,* Newmont Mining Corp., Carlin, NV

Eocene dikes in Carlin trend gold deposits provide practical information on the age, structural setting, and depth of sedimentary rock-hosted gold mineralization, which can be integrated into conceptual exploration modes: 1) crosscutting relations between well-characterized dikes and gold mineralization provide tight constraints on the age of mineralization at many deposits, including Betze-Post, Beast, Meikle, and Genesis. Alteration minerals in highly mineralized dikes at Meikle also are Eocene, and unlike Paleozoic host rocks, the dikes lack effects of pre-gold alteration; 2) syn-mineral dikes offer important information on the Eocene paleostress field; faults active during dike emplacement are important ore controls. At Deep Star, evidence suggests right-normal movement on ore-bounding N-striking faults/dikes, left-normal movement and dilation on NE linkage faults/dikes, and N69^{0}W extension; and 3) glassy, other textures and nearby coeval volcanic rocks at similar elevations suggest shallow levels (≤2km) of mineralization.

Establishing a Credible Geologic Model; Remapping the Cripple Creek District and Its Implications for Exploration and Environmental Models: *E. P. Jensen,* Univ. of Arizona, Tucson, AZ

The Cripple Creek gold deposit (22 M oz production, 6 M oz reserve) is hosted by a 30 Ma multi-phase alkaline diatreme complex. Since discovery in 1891, the district has been the subject of many theses, company and government reports, but none have documented the broad extent of alkali-feldspar and carbonate-rich metasomatism surrounding the high-grade vein systems or how these metasomatic features relate to the evolution of the volcanic complex. Remapping surface exposures and detailed relogging of deep drill core has generated a new model for the development of gold mineralization. Integrating the igneous and hydrothermal history of the deposit has and will continue to allow for effective exploration and has provided critical data for environmental models.

GEOMECHANICS II: MINE DESIGN ISSUES

2:00 PM — Tucson 40

Chair: D. Dolinar, NIOSH, Pittsburgh, PA

The Application of Geotechnical Monitoring to Stability Evaluation and Mine Design: *H. Maleki,* Maleki Technologies, Inc., Spokane, WA

In this paper, long-term measurements, and stress analyses in five underground mines are presented to demonstrate the application of measurements to stability evaluations and design of underground excavations. These case studies address both global aspects of strata response to mining activities as well as local ground behavior and support loading. The measurements utilized in this paper include both static (stress and deformation) and geophysical. Case studies quantify pillar behavior, roof deformation patterns, overburden response, and microseismic activities. Large-scale studies quantify periodic nature of overburden deformation and collapse. Local measurements address yield and stiff pillar load-deformation characteristics as well as the performance of support systems under combined axial and lateral loads.

Magma Porphyry

United States Department of Agriculture
Forest Service
Tonto National Forest
Globe Ranger District
7680 S. Six Shooter Canyon Rd.
Globe, AZ 85501
Phone: 520.402.6200
Fax: 520.402.6292

File Code: 1950
Date: March 1, 2001

State of Arizona
ATTN: Mr. Ken Phillips
AZ Department of Mines & Minerals
1502 W. Washington
Phoenix, AZ 85007

Dear Mr. Phillips:

The Globe Ranger District of Tonto National Forest is seeking public and agency comment on a proposed exploration-drilling program.

Kennecott Exploration Company is proposing to drill six mineral exploration holes from six drill pad locations east of Superior Arizona, at the locations shown on Figure 1 (attached). The drill sites are located in Section 32, Township 1 South, Range 13 East; Section 1 and 6, Township 2 South, Range 12 East; and Section 1, Township 2 South, Range 13 East.

Five of the drill pads sites (sites A, B, C, D, and F) have been previously occupied by drill rigs or are located on existing ground disturbance. In addition, these sites are accessible from existing Forest Road (FR) #2474. Sites B and C will require minor amounts of new disturbance to expand the drill pad areas. Site G will require construction of a new segment of road approximately 1,000 feet long, and a new drill pad site, approximately 40 feet by 100 feet.

The existing access road will require widening or filling in some places to accommodate the large size and low ground-clearance of the drill rigs.

The total amount of disturbance, including previously disturbed areas, is expected to be about 4 acres. New disturbance is estimated to be less than 2 acres.

The duration of the drilling program is expected to be approximately 18 months. The drilling program will operate around the clock and FS #2474 will be closed to the public during the drilling program. As many as four drill rigs may be operating at any given time.

The drilling process will require the use of water and drilling "muds" (bentonite clay), which will be recirculated or stored in small-excavated pits.

A bond covering the projected costs of reclamation would be required before approval of the Plan of Operations.

Your **written** comments, concerns, and suggestions are very important to us. Comments will have the greatest influence on the analysis if received at the address below within 30 days of the date of this notice. Please send your comments to:

Globe Ranger District
ATTN: Larry Widner, District Ranger
7680 S. Six Shooter Canyon Road
Globe, AZ 85501

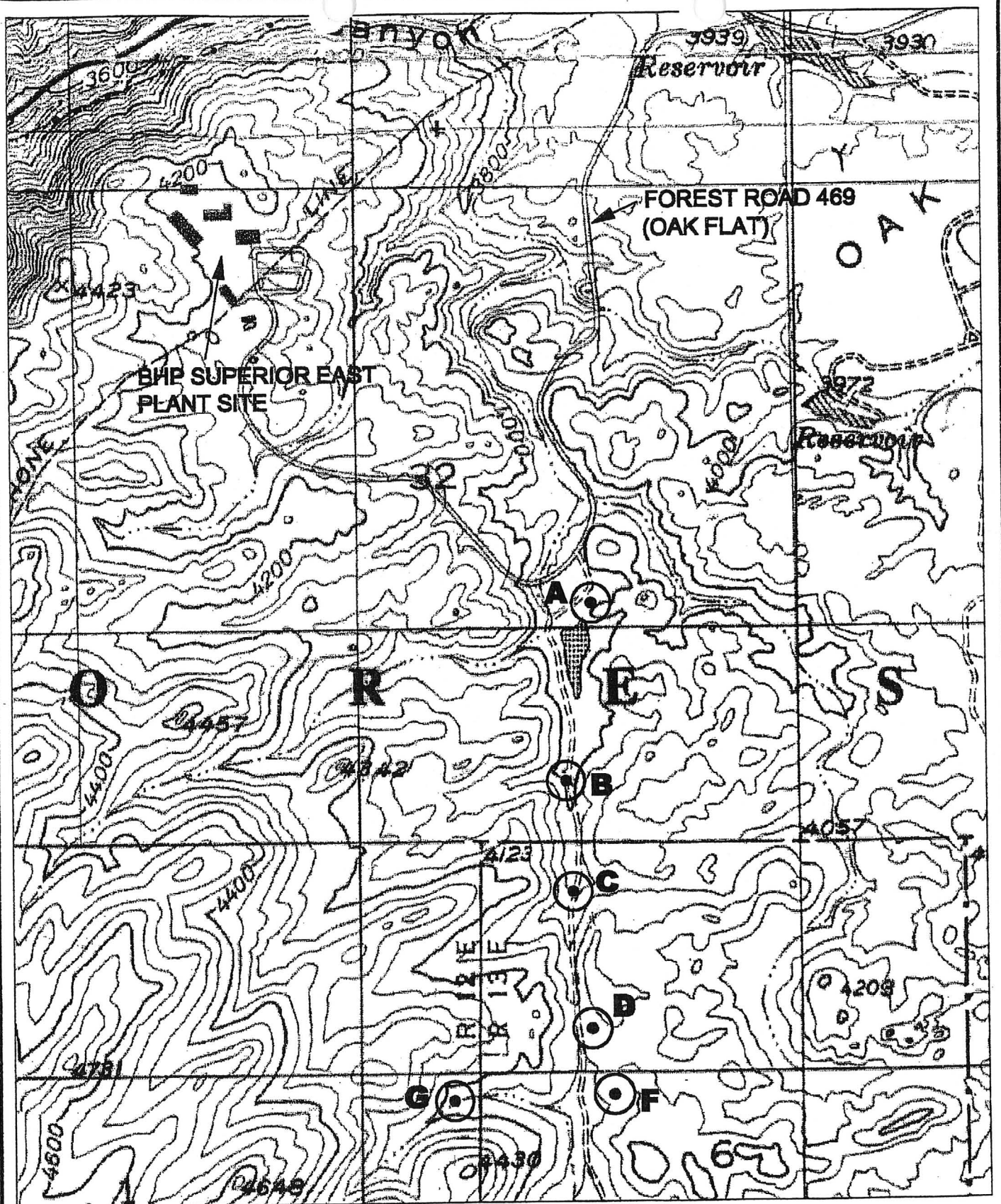
Comments received in response to this solicitation, including names and addresses of those who comment, will be considered part of the public record on this proposed action and will be available for public inspection. Comments submitted anonymously will be accepted and considered. Additionally, pursuant to 7 CFR 1.27(d), any person may request the agency to withhold a submission from the public record by showing how the Freedom of Information Act (FOIA) permits such confidentially. Persons requesting such confidentiality should be aware that, under the FOIA, confidentiality may be granted in only very limited circumstances, such as to protect trade secrets. The Forest Service will inform the requester of the agency's decision regarding the request for confidentiality, and where the request is denied, the agency will return the submission and notify the requester that the comments may be resubmitted with or without name and address.

Key contact for this proposed action scooping process is Stu Herkenhoff, Mineral Management Specialist, Globe Ranger District 7680 S. Six Shooter Canyon Road, Globe, AZ 85501. Should you need more information or have questions, you can contact Stu at the number above.

Sincerely,

LARRY WIDNER
District Ranger

Enclosures



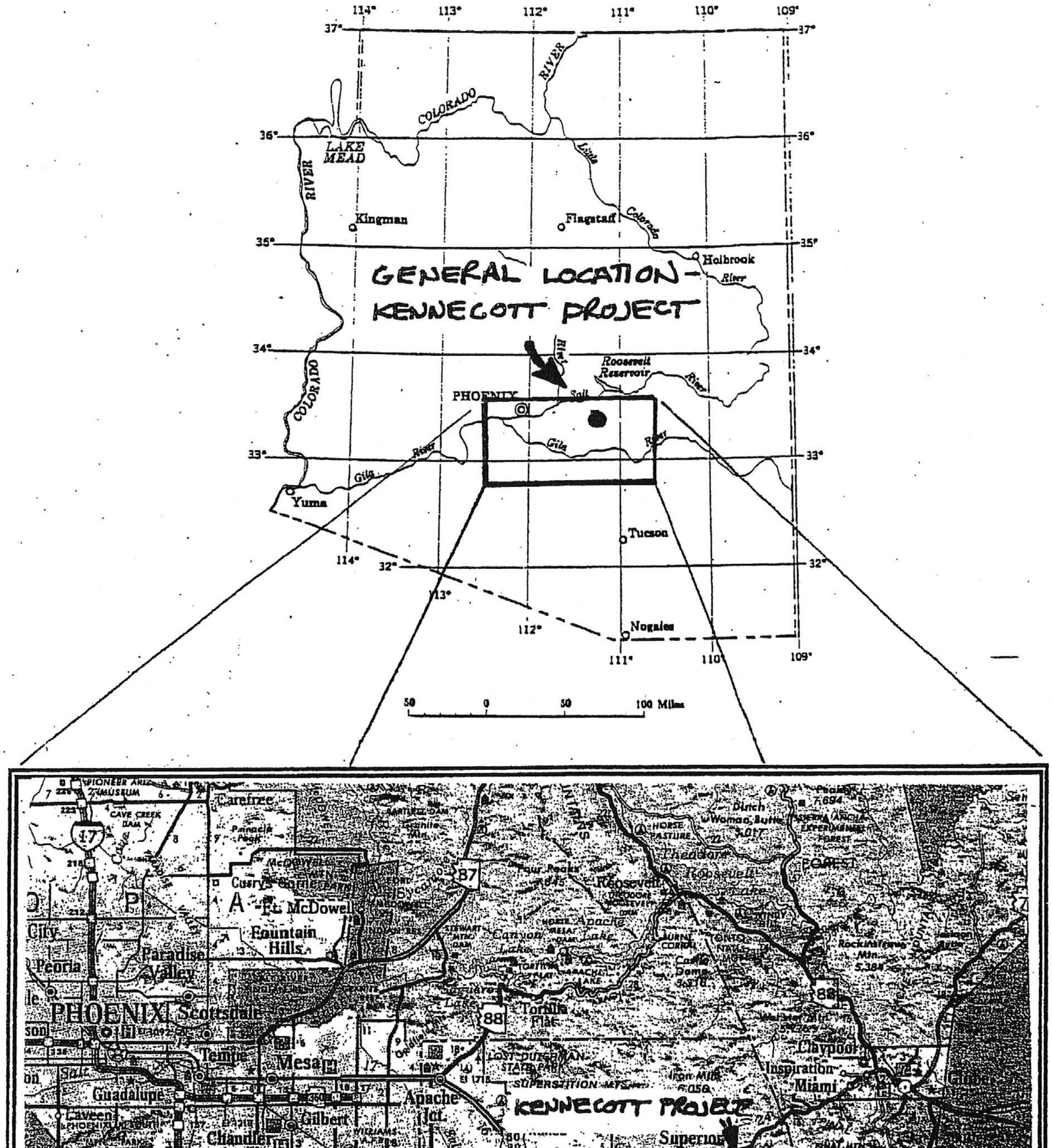
USGS 7.5' QUADRANGLE: SUPERIOR, ARIZONA

DATE:	PROJECT NUMBER:
1/2001	69

Whitman & Company
Environmental Permitting & Regulatory Compliance

0 500 1000
Approximate Scale in Feet

DRILL SITE LOCATION MAP



GENERAL LOCATION-
KENNECOTT PROJECT
COLORADO
RIVER
LAKE MEAD
Little Colorado
Kingman
Flagstaff
Holbrook
River
Roosevelt Reservoir
Salt
PHOENIX
Gila
River
Yuma
Tucson
Nogales
114°
113°
112°
111°
110°
109°
37°
36°
35°
34°
33°
32°
50
0
50
100 Miles
KENNECOTT PROJECT
PHOENIX
Scottsdale
Tempe
Mesa
Chandler
Gilbert
Apache Jct.
Superior
Miami
Globe
Florence
Kearny
Hayden
Casa Grande
Coolidge
Carefree
Fountain Hills
Paradise Valley
Peoria
Guadalupe
Higley
Queen Creek
Tortilla Flat
Claypool
Inspiration
Kelvin
Riverside
Christmas
Winkelman
Dudleyville
Maricopa
Stanfield
Francisco Grande
Randolph
La Palma
Valley Farms
Dadius Forest
Florence Jct.
Canyon Lake
Apache Lake
Theodore Roosevelt Lake
Roosevelt
Ft. McDowell
North Butte 2,980

MAGMA PORPHYRY AT PINAL CO

Nyal Niemuth

From: "Hoag, Cori CL" <Hoag.Cori.CL@bhp.com>
To: <njn22r@hotmail.com>
Sent: Friday, April 27, 2001 3:50 PM
Subject: FW: BHP COPPER SUPERIOR OPERATION-KENNECOTT EXPLORATION COMPANY JOINT VENTURE

FYI Cori

> -----Original Message-----
> From: Perry, John JT
> Sent: Thursday, April 26, 2001 5:35 PM
> To: COPNASMN-MSG01 Mail Clients
> Subject: BHP COPPER SUPERIOR OPERATION-KENNECOTT EXPLORATION COMPANY
> JOINT VENTURE
> Importance: High
>
> As part of our ongoing process to evaluate all options for our facilities,
> I am pleased to announce we have signed an agreement with Kennecott
> Exploration Company regarding the Superior facility. I believe execution
> of the terms of this agreement is a great outcome for BHP shareholders,
> employees and the community. For additional information, please see the
> attached document which is the text that will be published in the Superior
> Sun newspaper next week.
>
> At BHP Copper, we recognize the strong mining legacy of which we are a
> part, and are proud of the contributions our industry has made to this
> region. As we move into the next century, we are constantly looking for
> ways to manage our mining resources, and ensure the well being of our
> employees and the community.
>
> On Tuesday, April 17, 2001, BHP Copper and Kennecott Exploration Company
> of Salt Lake City, Utah, entered into an agreement whereby Kennecott will
> conduct exploration drilling activities in an area where BHP Copper has
> the mineral claims near Superior. The exploration activities will be in
> and around the mineral resource known as the Magma Porphyry. Porphyry is a
> geologic term used to describe certain types of copper deposits. "We feel
> that the Magma Porphyry resource has the potential to yield significant
> copper reserves," said John Perry, President of BHP Copper North America.
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> "Our arrangement with BHP Copper allows Kennecott Exploration Company an
> opportunity to expand upon previous exploration efforts in a prominent
> mining district," said Bruno Hegner, General Manger-Commercial, Kennecott
> Exploration Company.
>
> The terms of the agreement allow Kennecott Exploration Company to earn 55%
> of the project upon spending $25 million over six years. Kennecott
> Exploration Company can withdraw from the project at any time prior to
> earning in. As it has done in the past, BHP Copper will continue to keep
> the community apprised of any changes or new arrangements that could lead
> to further copper extraction in Superior.
>
> For more information, please call Mr. Charles Taylor, Director of

> Environmental and External Affairs, BHP Copper, at (520) 498-4101, or Mr.
> Bruno Hegner, General Manager-Commercial, Kennecott Exploration Company,
> at (604) 669-9953.

Growth and Technology
BHP Copper

Memorandum

7 May, 1998

TO: e-mail Distribution

cc:

FROM: Eric Seedorff

PUBLIC INFORMATION ON THE MAGMA PORPHYRY DEPOSIT, SUPERIOR DISTRICT, ARIZONA

After several requests for information, I have compiled the public information available on the Magma Porphyry deposit at Superior, from the releases to the Quarterly Report on Exploration and Development, December 1997-February 1998, to the Australian Stock Exchange and the BHP Investor Relations Bulletin (8 April 1998). You may distribute this to anyone inside or outside of BHP.

Superior, Arizona, USA

Exploration drilling continued near BHP Copper's Superior mine, which was closed in June of 1996. A new porphyry copper deposit with high primary copper grades has been discovered south of historic underground workings in the district, deeply buried under post-mineral rocks. The mineral deposit, named the Magma Porphyry, now has been intersected by five holes that were drilled between October 1995 and January 1998. The first three were long holes that were inclined laterally and downward from underground mine workings. The latest two holes were deep, steeply inclined holes drilled from the surface. All five holes have significant intercepts of greater than 1% copper, and all five terminate in well mineralized rock. The longest intercept is from one of the surface holes; assays of drill core from the bottom 306 metres (1,004 feet) yielded arithmetic mean grades of 1.75% copper and 0.029% molybdenum, and the last 188.7 metres (619 feet) of that interval assayed 2.18% copper and 0.028% molybdenum.

The dimensions of the Magma Porphyry deposit are still incompletely defined, but it is at least 300 metres high, 700 metres long, and 200 meters wide. The top of the deposit is approximately 1.3 kilometres beneath the surface. The existing infrastructure at Superior is not suitable to exploit the new deposit, but the results of preliminary studies indicate that the deposit may be amenable to conventional bulk tonnage, underground mining methods and flotation processing. At the end of the quarter, exploration drilling had ceased; the mine remained on a care-and-maintenance basis; and BHP was evaluating options for future exploration.

Eric Seedorff
Vice President Mineral Resources

Arizona Department of Mines and Mineral Resources
Verbal Information Summary

Mine: Magma Porphyry
County: Pinal
Location: uncertain.
approximately T2S, R13E, Sec. 6

Date: May 5, 1998
Engineer: Nyal Niemuth

Information from Dave Spatz, BHP Exploration, Tucson.

Mr. Spatz confirmed that BHP had announced discovery of a new porphyry copper system called the Magma Porphyry located about a mile to the south east of the Magma mine's number 9 shaft. It was discovered by the mine geologic staff (not BHP's exploration staff). It could possibly have been the source of the mineralization for the Magma vein and replacement ore bodies.

Although insufficient drilling has been done to fully delineate the deposit it could potentially contain a billion tons of mineralization. A couple hundred million tons at plus 1.0% Cu seems very likely. One 1,000 foot intercept ran 1.75% Cu. The character of the mineralization was reported as hypogene with chalcopyrite and bornite being the primary copper sulfide minerals. The mineralization occurs as stockworks and replacements of a hypabyssal volcanic.

The deposit is unfortunately very deep, approximately 1 mile, and thus very expensive to drill with holes costing between $250,000 and $500,000. The depth and high temperature (140 degrees F.) of the deposit would also contribute to high production costs. At present the company is suffering from the low copper prices and does not deem the deposit economic enough to spend further funds delineating it. In fact the pumps at the Magma mine have been turned off, saving the monthly operating cost of $100,000.

It is estimated that it would take perhaps $20 million for a couple of years to fully drill the deposit and maybe $100 million to sink a shaft. It was speculated that if production were to occur it was likely a tunnel would be made connecting it to the quite distant Pinto Valley mine's facilities.

History of exploration at the Magma Mine, Superior, Arizona

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ABSTRACT

The Magma mine at Superior, Arizona had a production history spanning 84 years, yielding some 24.5 million tonnes of ore grading nearly 5% Cu from Cordilleran veins and massive carbonate replacement mantos. The recent discovery of a large porphyry center 2 km south of the historic mine now indicates that the Superior (Pioneer) mining district holds a much larger mineral endowment than the first nine decades of mining ever managed to extract. The porphyry system was identified in core holes drilled between 1992 and 1998; the culmination of a mine- and district-scale exploration program originally aimed at delineating additional high-grade reserves for the Magma mine. Results at that time indicated a mineralized deposit at least 750 m long by 250 m wide by 300 m high with hypogene copper mineralization grading >1% Cu. Recent published estimates suggest that the porphyry resource exceeds 1 billion tons of 1.5% Cu (Robertson, 2004).

The porphyry discovery resulted from district-scale exploration that commenced in 1970 near Arizona's largest Cordilleran vein deposit, the Magma vein. Over the course of most of the 20th century, the Magma Copper Company exploited this vein to a depth of 1500 meters below surface and 2.5 km eastward from No. 1 Shaft under the Apache Leap plateau. Mine development followed vein and replacement orebodies eastward beneath Tertiary cover where in 1959 a large block of Mesozoic volcanic and clastic sedimentary rocks was encountered to the south of the carbonate replacement mantos. This block of Mesozoic rocks proved to be mineralized by small but high-grade copper veins that stimulated interest in the possibility that other vein and/or replacement lodes might lie undiscovered in the district. Evaluation of the structural and stratigraphic implications of the Mesozoic block, hidden beneath the Apache Leap plateau, has since been the key to locating additional copper resources in the Magma mine and the adjacent district. Holes drilled from surface to test the postulated south boundary of the Mesozoic block, between 1972 and 1981, failed to locate the structure.

When the mine reopened in 1990, after shutdown in 1982, exploration was continued to the south. Surface drill hole MB-9, collared in 1991, was the first of several that cut Mesozoic rocks altered to quartz, sericite, pyrite and cut by copper veins. Underground drill hole 36108-S27E in 1994 intersected a wide zone of Mesozoic clastic rocks exhibiting quartz-sericite-pyrite alteration and cut by thin chalcocite veins surmised to lie at a high structural level over a concealed porphyry system. Underground drill hole 36108-S27H inclined southerly into a zone exhibiting secondary biotite (potassic alteration) with grades near 2% Cu indicated the potential for an economically viable deposit. Four additional drill holes produced intercepts with grades indicating a system capable of sustaining grades above 1% Cu.

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Paul, Alex H., and Manske, Scott L., 2005, History of exploration at the Magma Mine, Superior, Arizona, *in* Rhoden, H.N., Steininger, R.C., and Vikre, P.G., eds., Geological Society of Nevada Symposium 2005: Window to the World, Reno, Nevada, May 2005, p. 629–638.

THE RESOLUTION COPPER DEPOSIT, A DEEP, HIGH-GRADE PORPHYRY COPPER DEPOSIT IN THE SUPERIOR DISTRICT, ARIZONA

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Kennecott Exploration Company

INTRODUCTION

Manske and Paul (2002) described a recently discovered, deep, high-grade porphyry copper deposit in the Superior (Pioneer) district of Arizona. Their description, written after just five core holes had intersected an apparently coherent zone of >1% Cu mineralization, provides a remarkably complete picture of the upper parts of the mineralized system.

Following initial drilling, which was carried out by Magma Copper Company and by BHP, Kennecott secured an option to earn a 55% interest in the copper deposit through further exploration expenditures. The deposit was named the Resolution deposit and a program of deep surface drilling commenced in July 2001. Since that time 17 additional deep core holes have been completed, most of them to depths of more than 2000m. This paper, which is intended to accompany an oral presentation, provides an update of the geology of the deposit based on drilling through hole RES-5B completed in January 2003.

LOCATION AND DISCOVERY

The Resolution deposit lies within a prominent ENE-trending, 50km-long belt of porphyry copper deposits and related copper-bearing veins and mantos that extends from the Magma mine in the southwest to the Old Dominion mine in the northeast (Peterson, 1962). Resolution lies immediately southeast of an east-west trending zone of vein and manto deposits developed by the Magma mine, and 3.5km southwest of the undeveloped Superior East deposit, a zone of buried vein-controlled and disseminated bornite-chalcocite mineralization reported by Sell (1995).

From 1972 or earlier, it had been recognized that a porphyry copper deposit probably lay concealed beneath post-mineral formations in the Superior district (Hammer, 1972; Einaudi, 1982). However, mining economics always dictated that exploration was directed at discovery of high-grade vein and replacement ores. In 1991 Mark Sander and others within Magma Copper initiated an aggressive new program of surface and underground exploration for additional vein and replacement ores to augment the reserves of the Magma mine. Sander invited participation by Don Hammer, Marco Einaudi, and several graduate students from Stanford University (Don Hammer, pers. comm., 2001).

The Resolution deposit was ultimately discovered by underground drilling in 1995 and 1996. A subhorizontal hole, S27E, drilled to the south from the 3600 level of the Magma mine, was completed in February 1995. It intersected sericitized rocks carrying abundant pyrite and several veins containing hypogene chalcocite. Magma's exploration team surmised that these rocks must overlie a porphyry copper deposit (Manske and Paul, 1996) and drilled a follow-up hole beneath the first hole. The follow-up hole, S27H, completed in January 1996, passed out of the sericitized and pyritized rocks into biotite-altered rocks carrying strong porphyry-style chalcopyrite mineralization. The last 43m of S27H averaged 1.94% Cu.

Regional & District Geology

The regional setting and economic geology of the Superior district are well documented (Sell, 1961; Gustafson, 1962; Hammer and Peterson, 1968; Peterson, 1969; Schott, 1994; Paul and Knight, 1995; Friehauf, 1998: Pareja, 1998; and Manske and Paul, 2002).

The Resolution deposit underlies a plateau comprised of post-mineral welded tuff that caps a north-trending mountain range. Listric basin and range type faulting has tilted the mountain range to the east and exposed Lower Proterozoic through Pennsylvanian sedimentary rocks along the western flank of the range.

The Proterozoic rocks consist of 1.7 Ga quartz-mica Pinal Schist and a 40° east-dipping sequence of relatively unmetamorphosed shales, quartzites, and limestones of the Upper Proterozoic Apache Group. The sediments are intruded by thick sills of diabase that have been dated at 1.04 to 1.12 Ga in the Ray mine 15km to the south (Banks et al., 1972).

A sequence of platform sediments disconformably overlies the Proterozoic rocks and likewise dips at about 40° to the east. It includes the Cambrian Bolsa Quartzite, Devonian Martin Formation (mostly dolostone), Mississippian Escabrosa Formation (mostly limestone), and the Pennsylvanian Naco Formation (mostly limestone). Permian and Cretaceous rocks are present but only known from drilling.

Underground workings and drilling have identified an unusual 1.5km north-south by 1.5 to 2.5km east-west "graben" beneath the Tertiary cover rocks that contains a 1300m-thick package of volcaniclastic rocks, tuffs, pebbly sandstone, and conglomerate. Correlation has been proposed with Cretaceous rocks exposed near the Christmas mine 40km to the south (Hammer, 1972; Schott, 1994; Manske and Paul, 2002). The northern boundary of the graben has been cut in mine headings and numerous underground drill holes where it is a steeply dipping mineralized fault. The other boundaries are poorly defined.

Tertiary post-mineral cover rocks include an eastward-thickening wedge of fluvial conglomerate and overlying lacustrine sandstone collectively known as the Whitetail Conglomerate and a welded dacitic tuff sheet known as the Apache Leap Tuff. The Whitetail Conglomerate feathers out 1km to the west of the Resolution deposit, is 450 to 600m-thick over the deposit, and thickens to more than 1500m adjacent to the Devil's Canyon growth fault 2km to the east of the deposit. The overlying Apache Leap Tuff is a 400 to 500m-thick, sub-horizontal layer of welded 18.6 Ma dacite tuff. It forms an extensive rocky plateau bounded by cliffs that exhibit spectacular columnar jointing.

Only minor volumes of felsic intrusive rocks are exposed at surface in the district. The Silver King stock, a 2 by 3km, quartz diorite stock intrudes Proterozoic and Paleozoic rocks 6km NW of the Resolution deposit. Narrow felsic dikes and sills cut the Paleozoic carbonates at the surface west of the deposit and in mine workings (Hammer, 1972).

There are no currently active mines in the Superior district. Early production was of native silver from east-trending veins that cut the Proterozoic and Paleozoic rocks. Below the oxide zone, the veins were found to carry bornite, chalcocite, chalcopyrite, tetrahedrite, and sphalerite, and in the Magma mine, the largest mine, the veins were followed eastward for 3km. From the mid 1960s through closure in 1996 most of the production from the Magma mine was from chalcopyrite-bornite-chalcocite-pyrite-specularite mantos within the Paleozoic carbonate sequence adjacent to the veins. The district has produced 24.5 million tonnes of ore grading nearly 5% copper (Paul and Manske, 1999).

GEOLOGY OF THE RESOLUTION DEPOSIT

Figure 1, a cross section through the Resolution deposit and Shaft 9 of the Magma mine, illustrates many of the geological features described below.

Proterozoic Rocks

Fragments of quartz-mica schist presumed to be derived from the 1.7 Ga Pinal Schist have been observed in Resolution drill core as xenoliths in dikes and as clasts in breccias but the schist has not yet been intersected in-situ.

Younger Proterozoic sedimentary rocks and/or diabase have been intersected in 16 of the 17 deep core holes drilled by Kennecott. The only hole that failed to intersect the Proterozoic rocks remained within a dike. Proterozoic rocks and breccias developed within them host the majority of the Resolution copper mineralization (84% of the material within the >1% Cu zone).

The Proterozoic sediments comprise an upward-younging sequence that has been correlated with the Upper Proterozoic Apache Group. The sequence cut by drilling, from oldest to youngest, is as follows:

- Dripping Spring Quartzite: Individual intervals of white to buff orthoquartzite up to 130m thick in several drill holes in the southeast sector of the deposit have correlated with the Dripping Spring Quartzite. The stratigraphic base of the quartzite has not been penetrated. It is always underlain by diabase or quartz monzonite.

- Mescal Limestone: Wide, structurally thickened intersections of mineralized and altered limestone in several drill holes in the northwest sector of the deposit have been correlated with the Mescal Limestone. The Mescal is typically underlain by diabase.

- Apache Basalt: Up to 10m of vesicular basalt locally overlies the Mescal. This basalt has been correlated with the Apache Basalt.

- Troy Quartzite: Up to 80m of arkosic quartzite and siliceous siltstone comprise the shallowest Proterozoic rocks intersected in the northwest sector of the deposit. These rocks have been correlated with the Troy Quartzite.

Thick diabase sills intrude the older parts of the Apache Group sediments and are important hosts to copper mineralization. One hole, RES-2A intersected multiple diabase sills over a vertical interval of 400m. Several holes bottomed in diabase. The diabase, which is typically dark-gray to black, consists of medium-grained, sub-ophitic intergrowths of plagioclase, pyroxene, and lesser quantities of amphibole, biotite, and Fe-Ti oxides. It is strongly magnetic except where it is well mineralized. Textures range from aphanitic to nearly pegmatitic, to strongly amygdaloidal. The diabase is an excellent host for copper mineralization, accounting for 40% of the material within the >1% Cu zone.

Volcaniclastic Rocks

Tuffs, volcanics sediments, conglomerates and sandstones ("volcaniclastic rocks") that lie within a local depression concealed beneath the post-mineral cover rocks host the uppermost part of the Resolution copper deposit and most of the overlying pyrite halo. They account for 9% of the material within the >1% Cu zone.

The volcaniclastic rock package includes crystal and lithic tuff, immature volcanic sediment, pebbly sandstone and cobble conglomerate. Lithic fragments in the tuffs include most of the older rock types exposed in the district. Quartz porphyry fragments locally predominate. Some well-mineralized horizons within the porphyry deposit are tuffs (Proffett, 2001). Elsewhere the rock package consists mostly of sedimentary rocks and includes abundant quartzite and chert clasts (Schott, 1994).

The volcaniclastic rocks are underlain by sedimentary rocks of the Upper Proterozoic Apache Group. Quartz-rich sandstones and quartzite-rich conglomerate in the lower part of the volcaniclastic rock package are not readily distinguishable from the Upper Proterozoic Troy Quartzite. Based on drilling to date, the unconformity between the two rock packages appears to dip gently to the west. Faulting is not obvious at this contact; it appears to be depositional.

Hammer (1972, p. 25) reports that volcanic sediments dip at 18° to 22° to the east on the 3600 level of the Magma mine and Schott (1994, p. 26) reports an average dip of 36° to the southeast based on mapping of the 3600-3800 level ramp system. These dips approximate the dip of the base of the overlying Whitetail Conglomerate but do not conform to the underlying Proterozoic erosional surface. The volcaniclastic rocks are sufficiently poorly sorted that bedding cannot be reliably determined from drill core.

The geological setting of the volcaniclastic rocks is perplexing. The depression that has preserved them from erosion is almost equidimensional. If it is bounded to the north and south by east-trending faults, those faults do not extend far enough to the west to emerge from beneath the Tertiary cover, and they do not appear to be long enough to define a graben. Within the depression, the volcaniclastic rocks are sitting unconformably on the Upper Proterozoic rocks, with the entire Paleozoic section missing.

Blocks of carbonate rock up to meters across are present near the base of the volcaniclastic rocks and one interpretation suggested for these is that they may have fallen from a steep-walled void of some kind in the Paleozoic carbonate rocks. It is tempting to explain the void as an eruption feature. However, the lower part of any such feature has apparently been removed by some combination of faulting and erosion.

Intrusive Rocks

Felsic intrusive rocks are much less common at Resolution than in most porphyry copper deposits. Only 7% of the material within the >1% Cu zone is intrusive rock.

Quartz-Eye Porphyry: The most ubiquitous intrusive rock is a gray to white to tan porphyry consisting of phenocrysts of biotite, quartz, plagioclase ± K-feldspar in an aphanitic matrix. The quartz eye porphyry is cut by the feldspar porphyry described below and is probably the oldest Laramide intrusive rock.

Feldspar Porphyry: A less-crowded porphyry with quartz, plagioclase and biotite phenocrysts in an aphanitic groundmass is less common than the quartz eye porphyry and tends to occur deeper in the deposit. The feldspar porphyry cuts the quartz-eye porphyry but its age relative to the quartz monzonite porphyry is not established. On average, the feldspar porphyry within the >1% Cu zone carries slightly stronger copper mineralization than the quartz-eye porphyry. We suspect that it is closely associated temporally and genetically with the quartz monzonite porphyry.

Quartz Monzonite Porphyry: A white to buff, crowded quartz monzonite porphyry carrying abundant phenocrysts of biotite, quartz, plagioclase and K-feldspar within a fine-grained but holocrystalline matrix has been intersected in three deep core holes (RES-2A, RES-3, and RES-5). The quartz monzonite porphyry is inferred to be part of a larger stock that may be the source of the copper and molybdenum mineralization but is itself only weakly mineralized. Preliminary $^{40}Ar/^{39}Ar$ ages of 62.69 and 62.39 Ma for biotite phenocrysts and hydrothermal sericite respectively from the quartz monzonite probably bracket the age of mineralization (unpublished dates, New Mexico Institute of Mineral Technology).

Dike Orientations: The orientation of dikes is difficult to determine from sparse drilling and the margins of the dikes at Resolution are typically faulted making it difficult to obtain useful information from oriented drill core. Available drilling suggests that the quartz eye porphyry occurs as plugs, sills, and as an ENE-trending swarm of dikes. Feldspar porphyry dikes striking between ENE and east have been mapped along the Apache Leap range front and dikes follow many of the faults occupied by veins in mine workings (Hammer, 1972).

Heterolithic Breccia: A matrix-poor breccia occurs as irregular bodies that crosscut the Proterozoic rocks near center of the deposit (Figure 1). Breccia clasts include angular to rounded fragments of diabase, quartzite, schist, quartz eye porphyry, and fragments of strained quartz veins. The matrix typically consists of hydrothermal biotite. The breccia mostly commonly occurs within diabase.

Structure

As noted in an earlier section, large displacement, steep faults (concealed beneath the younger welded tuff sheet) appear to bound the Cretaceous volcaniclastic rocks. Even older faults may cut the Proterozoic rocks but not the Mesozoic rocks. Fortunately, most or all of the displacement on such early faults probably pre-dates the copper and molybdenum mineralization. To the extent that they can be defined by widely spaced drilling, broad patterns of alteration and mineralization zoning do not appear to be severely disrupted by post-mineral faulting.

Down-to-the-west movement on the Devil's Canyon fault appears to have rotated a 6km-wide fault block between the Devils Canyon and Concentrator faults to the east. The base of the 18.6 Ma Apache leap tuff dips at approximately 12° to the east above the Resolution deposit, while the base of the mid-Tertiary Whitetail Conglomerate dips to the east at approximately 25°. These relationships suggest that the Resolution deposit itself has probably been rotated to the east by about 25° and that about half of that rotation happened during deposition of the Whitetail Conglomerate.

Kennecott mapping has defined a detailed stratigraphy for the upper part of the welded tuff sheet. This has permitted the identification of several minor NW-trending faults with offsets from a few meters to a few tens of meters that cut the welded tuff sheet in the vicinity of the Resolution deposit. Manske and Paul (2002) also described a north-south trending fault zone named the Anxiety fault zone that crosses the center of the deposit. The Anxiety fault shows no appreciable post-18.6 Ma displacement.

Approximately 1500m of oriented core has been collected during Kennecott's drilling and orientations have been recorded for approximately 100 post-mineral shears. Two strong clusters of shears have mean orientations as follows: 060°/78° SE and 075°/52° NW (Hart and Hehnke, 2002).

A locally strong shortening and shear fabric is observed in several deeper intersections of diabase. The fabric is expressed as millimeter-scale, flattened, parallel, disk-shaped clots of biotite and grossly parallel chloritic sheared bands. Measurement of this fabric in oriented core suggests that the fabric defines an elongate dome-shaped pattern, the crest of which trends northward (Hart and Hehnke, 2002).

Veinlets that pre-date quartz-pyrite "D" veinlets, including milky quartz veins, magnetite-biotite veins, quartz-molybdenite veins, and the earliest chalcopyrite-pyrite veinlets, are folded and flattened parallel to the foliation in the diabase. Some early chalcopyrite-pyrite veinlets are shortened enough to appear ptygmatic. Stylolitic joints are observed in the same plane as the shear fabric. Quartz-pyrite "D" veinlets and late bornite-chalcocite veins cut the foliation.

The foliation may have formed through softening of the host rocks in response to an upward migrating thermal front that overprinted the earlier mineralization. Folding of early veins and development of foliation during the main stage of chalcopyrite mineralization may have tended to seal the mineralizing system, helping retain metalliferous fluids within a volume of reactive diabase and limestone.

Hydrothermal Alteration

A PIMA infrared spectrometer has been used routinely to identify alteration species in drill core following the lead of a study by Troutman (2001). Drill core has also been examined under ultraviolet light to help distinguish fluorescent minerals and map crosscutting relationships between veins. Representative samples have been examined petrographically by one of us (T.M.) and by William Chavez. X-ray diffraction studies have been commissioned as a last resort to identify a few difficult to identify species.

Resolution host rocks exhibit strong pervasive hydrothermal alteration and obvious alteration zoning patterns are evident. The central part of the strongest copper mineralization is associated with either 1) abundant secondary biotite in volcaniclastic rocks, siltstone, breccia, and diabase, or 2) garnet-diopside skarn, variably retrograded to calcite, clays, chlorite, epidote, and actinolite, in what were originally calcareous sediments.

The deep lateral boundaries of the >1% Cu zone are poorly defined by drilling. However, volcaniclastic rocks, siltstones, and diabase from holes close to inferred boundaries show zoning outward from biotite-altered rocks with associated chalcopyrite-pyrite mineralization to chlorite-epidote altered rocks with mostly pyritic mineralization. The boundary between potassic alteration and propylitic alteration consistently shows biotite veinlets and vein selvedges *prograding* across pervasively propylitized rocks.

A thick zone of intense, pervasive quartz-muscovite-illite alteration overlies the central part of the copper mineralized zone. Over the center of the deposit, this zone of phyllic alteration extends upward for 400m with undiminished intensity to the erosional surface at the base of the Whitetail Conglomerate. Manske and Paul (2002) suggested that the phyllic zone transitions outward through an intermediate argillic zone to propylitized rocks.

Portions of the potassic zone and the entire quartz-muscovite-illite zone are commonly overprinted by structurally- and bedding-controlled advanced argillic alteration. Characteristic minerals include kaolinite, dickite, and zunyite. The advanced argillic alteration is spatially associated with late bornite-chalcocite mineralization.

Anhydrite is common in veins and as breccia matrix in deeper portions of the deposit. It is typically leached within zones affected by advanced argillic alteration. Gypsum is rare.

Mineralization

Resource Estimates: Kennecott and BHP Billiton have not announced resource estimates for the Resolution deposit.

Size and Shape of the Mineralized Zone: The best porphyry copper style mineralization occurs in a dome-shaped zone within which copper grades exceed 1% Cu *in the most receptive host rocks* (">1% Cu zone"; Figure 1). The dome-shaped zone, which is greater than 1000m in diameter, is underlain by a more gently dome-shaped lower-grade core. The apex of the >1% Cu zone lies 250m below sea level and the apex of the lower grade core lies 750m below sea level. The thickness, plunge, and depth extent of the lower edges of the copper "shell" between these surfaces are largely undefined.

Lithological Control of Copper Grades: Copper grades are strongly controlled by lithology. Diabase and limestone within the >1% Cu zone, locally carry more than 2% Cu but immediately adjacent quartz-eye porphyry dikes may carry less than 1% Cu and adjacent quartzite locally contains less than 0.5% Cu.

Molybdenite: Most molybdenite occurs in early quartz-molybdenite veinlets. Subordinate amounts occur as "paint" on slickensided surfaces. Quartz-molybdenite veins typically lack copper mineralization. They do not cut copper-bearing veins. Although molybdenum mineralization is demonstrably earlier than all stages of copper mineralization, the two metals are broadly co-spatial. Molybdenum grades decrease rapidly upward into the pyrite halo. They decrease less rapidly than copper grades downward into the lower grade core.

Early Chalcopyrite-Pyrite Mineralization: Early chalcopyrite-pyrite mineralization at Resolution is similar to that seen in the central zones of many porphyry copper deposits. However, the sulfide veinlets tend to be wider than in lower grade deposits and the chalcopyrite tends to be coarser-grained and less intimately intergrown with pyrite.

The pyrite to chalcopyrite ratio ranges from about 3:1 to 1:1 in the chalcopyrite-bearing part of the >1% Cu zone within volcaniclastic rocks and diabase, and it decreases systematically with depth in those rock types. It varies erratically in other rock types.

Roughly equal portions of the sulfide minerals occur as disseminations and as fracture fillings. Chalcopyrite and pyrite locally occur in veinlets with quartz and/or anhydrite but many veinlets lack appreciable volumes of gangue minerals.

Pyrite Halo: A halo of unusually strong pyrite mineralization overlies and flanks the >1% Cu shell. Pyrite abundance increases upward to a maximum of about 10 weight percent 100 to 200m above the upper boundary of the >1% Cu zone, then decreases further above the copper zone. Pyrite is most abundant in the quartz-muscovite-illite alteration zone above the >1% Cu zone but also extends laterally into adjacent propylitized rocks. Flat holes drilled from the 3600 level of the Magma mine, indicate decreasing pyrite content in the propylitized volcaniclastic rocks with increasing distance from the >1% Cu zone.

Late Bornite-Chalcocite Mineralization: Earlier chalcopyrite-pyrite mineralization is locally strongly overprinted by late bornite and/or chalcocite mineralization. The late bornite-

chalcocite mineralization is strongly controlled by permeability and is often less pervasive than the preceding chalcopyrite-pyrite or pyrite mineralization. Bornite and/or chalcocite have often replaced the chalcopyrite and pyrite in veinlets and in vein selvedges while chalcopyrite and pyrite further from veinlets may be incompletely replaced. Incomplete overprinting permits the upper boundary of the earlier chalcopyrite zone to be roughly defined. It appears that overprinting by bornite and chalcocite is strongest within the upper part of the chalcopyrite zone and the lower part of the pyrite halo.

Within overprinted zones, individual chalcopyrite and pyrite grains are commonly rimmed by or replaced with bornite. Replacement of bornite and pyrite by chalcocite appears to be a more fully developed stage of the same process as deposited bornite.

Bornite is most abundant in the volcaniclastic rocks, but traces of bornite occur throughout the deposit; bornite is often the predominant copper mineral in quartzites and quartz eye porphyry dikes, even in deeper parts of the deposit.

High-Grade Bornite-Chalcocite Veins: Two 1 to 3m-wide, steeply dipping, ENE-trending veins named the First South and Second South veins were developed by a crosscut to the south from the Magma mine on the 3600 level (Figure 1). The veins, which cut volcaniclastic rocks, carry abundant bornite and chalcocite (Schott, 1994). Similar but narrower veins were cut in some of the underground holes drilled across the top of the porphyry copper deposit and in RES-4B, one of Kennecott's surface holes. Drilling suggests that in the immediate vicinity of the porphyry deposit, high-grade, chalcocite-bornite veins are best developed between about 250m above sea level and 250m below sea level. They either die out upward and downward or, more likely, change to massive pyrite veins.

Sphalerite-Galena ± Chalcopyrite Veins in Propylitized Rocks: Thin quartz-sphalerite-galena±chalcopyrite veinlets are present in propylitized volcaniclastic sediments in Magma holes MB-11 and MB-11A on the southern margin of the Resolution deposit. Zoning is evident in these holes from sphalerite-galena veins at higher elevations to sphalerite-galena-chalcopyrite veins at greater depth. This zoning provides a vector toward porphyry-copper style chalcopyrite-pyrite mineralization.

Vein Orientations: Hart and Hehnke (2002) examined the orientations of 812 copper-bearing veins logged in oriented core. Approximately 70% of the oriented veins show apparently random orientations but about 30% of the veins fall within two clusters: 030°/60° NW and 050°/75° SE. Several chalcocite and bornite veins intersected in Kennecott drill hole RES-4B have strikes parallel to the First South and Second South veins.

Oxidation and Leaching at the Pre-Whitetail Paleosurface: A weathered and oxidized paleosurface is present beneath the Whitetail Conglomerate and has been cored in at least 20 drill holes. The depth of oxidation from the paleosurface to the top of continuous sulfides is highly variable, varying from 50m in Magma hole MB-10C to 322m in Magma hole MB-10A only about 100 meters away.

A strong "leached cap" characterized by abundant hematite and lesser jarosite is present in at least six holes. Core from holes that penetrate the base of hematitic capping suggests that the precursor mineral for most of the hematite is pyrite. Only a weak zone of supergene chalcocite deposition is present, typically with copper grades of less than 1%. The right processes seem to have occurred but leaching has affected only the pyrite halo of the deposit.

DISCUSSION

Geological History

The geological history of the area hosting the Resolution deposit, from Upper Proterozoic time onward, includes the following elements:

Deposition of quartz-rich sediments and limestones in Upper Proterozoic time
Emplacement of diabase sills and effusion of basalt (Apache Basalt) at ~1080 Ma
Deposition of carbonate-rich rocks on a continental shelf in Paleozoic time
Removal of the Paleozoic rocks by uplift or thrust faulting in post-Pennsylvanian time
Andesitic and dacitic orogenic volcanism, probably in the interval from ~100 to 70 Ma
Erosion of the volcanic rocks to form immature sediments
Development of a steeply bounded local depression that preserved the volcaniclastic rocks
Intrusion of the volcaniclastic rocks by dikes between ~70 and 65 Ma?
Emplacement of the Schultze Granite, a large ENE trending QMP stock at ~65 to 63 Ma, and development of a cupola beneath the Resolution deposit
Degassing of the QMP and/or other intrusions and generation of breccias
Separation of ore fluids from the deeper, last-to-crystallize portions of the QMP intrusion
Precipitation of quartz in early barren quartz veinlets
Precipitation of quartz and molybdenite in early veinlets
Deposition of veinlet and disseminated chalcopyrite and pyrite with accompanying potassic alteration
Deformation of all previously formed veins and local development of foliation in the diabase
Deposition of additional veinlet and disseminated chalcopyrite and pyrite with potassic alteration
Deposition of abundant veinlet and disseminated pyrite with accompanying illite-muscovite alteration
Replacement of earlier chalcopyrite and pyrite by bornite and chalcocite along with advanced argillic alteration
Oxidation of portions of the pyrite halo and precipitation of minor secondary chalcocite
West-side-down movement on the Devils Canyon fault, forming a half-graben
Deposition of Whitetail Conglomerate into the half-graben, covering the deposit
Eruption of the Apache Leap Tuff, protecting the deposit from erosion (and earlier discovery)
Continued Basin and Range style faulting

Causes for High Hypogene Copper Grades

The Resolution deposit exhibits higher hypogene copper grades than most other porphyry copper deposits in the southwestern USA. Two factors apparently combined to generate the higher grades: 1) favorable host rocks, and 2) superimposition of a late stage of bornite-chalcocite mineralization on earlier chalcopyrite-pyrite mineralization.

Favorable host rocks at Resolution include Proterozoic limestones and calcareous siltstones and Proterozoic diabase that originally contained abundant calcic plagioclase, hornblende and magnetite. As in some other porphyry copper districts (including Bingham; Atkinson and Einaudi, 1978; Harrison and Reid, 1997) interbedded unreactive quartzites and highly receptive lithologies may have been favorable for ore deposition. Thick, non-reactive quartzites at Resolution host only weak copper mineralization but may have channeled ore fluids for long distances to more favorable host rocks.

The Resolution porphyry displays strong late bornite-chalcocite mineralization that shows mineralogical similarities to late mineralization described at Butte (Proffett, 1979) and Collahuasi (Dick et al., 1994). This stage of mineralization is particularly important at Resolution because it not only generated large veins but also permeated significant volumes of rock in a manner similar to more common, early stage chalcopyrite-pyrite mineralization.

ACKNOWLEDGEMENTS

This paper is presented with the permission of BHP Billiton and Kennecott. We appreciate this permission and the consistent direction and financial resources made available by Kennecott and Rio Tinto management during the recent drilling program.

In addition to contributions by the authors and others cited, Tom Bourns, Jim Finch, Bill Hart, Jason Hefner, Katya Masun, Kierran Maher, Duane Olsen and Anne Pattison logged drill core, Miriam Hart managed the assay QA/QC program, Bill Hart and Tom Bourns led the effort to obtain and analyze oriented core, Jay Hammitt provided 3-D modeling support, Jon Gant mapped the post-mineral cover rocks, and William Chavez provided illuminating petrographic descriptions. Energetic geological discussions with all of these people and with Don Hammer, Scott Manske, Steve Potter, Alasdaire Pope and John Main are warmly acknowledged.

Dynatec Drilling, based out of Salt Lake City, did a superb job of deep directional core drilling.

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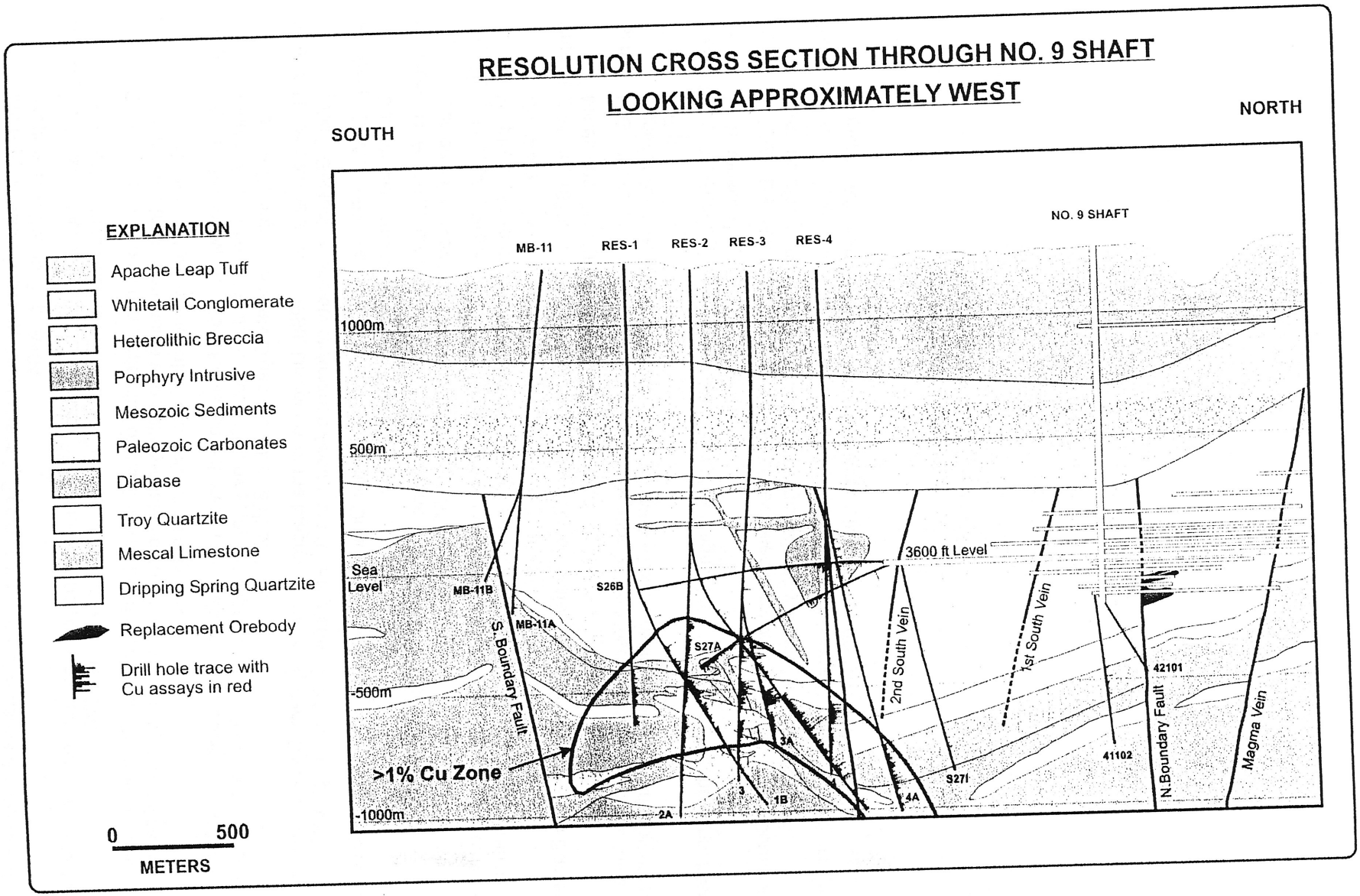
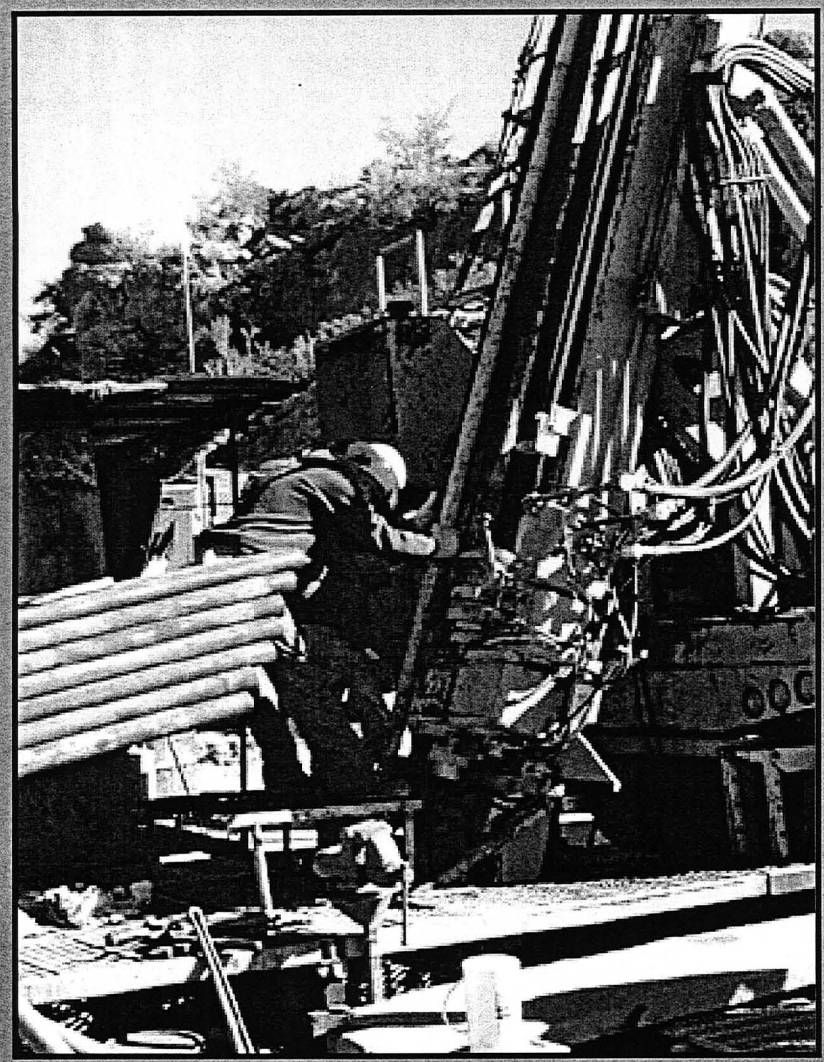

RESOLUTION CROSS SECTION THROUGH NO. 9 SHAFT
LOOKING APPROXIMATELY WEST
SOUTH
NORTH
EXPLANATION
Apache Leap Tuff
Whitetail Conglomerate
Heterolithic Breccia
Porphyry Intrusive
Mesozoic Sediments
Paleozoic Carbonates
Diabase
Troy Quartzite
Mescal Limestone
Dripping Spring Quartzite
Replacement Orebody
Drill hole trace with Cu assays in red
0
500
METERS
NO. 9 SHAFT
MB-11
RES-1
RES-2
RES-3
RES-4
1000m
500m
Sea Level
-500m
-1000m
MB-11B
MB-11A
S26B
S27A
3600 ft Level
S. Boundary Fault
2nd South Vein
1st South Vein
42101
41102
N.Boundary Fault
Magma Vein
>1% Cu Zone
3A
3
1B
2A
4A
S27I

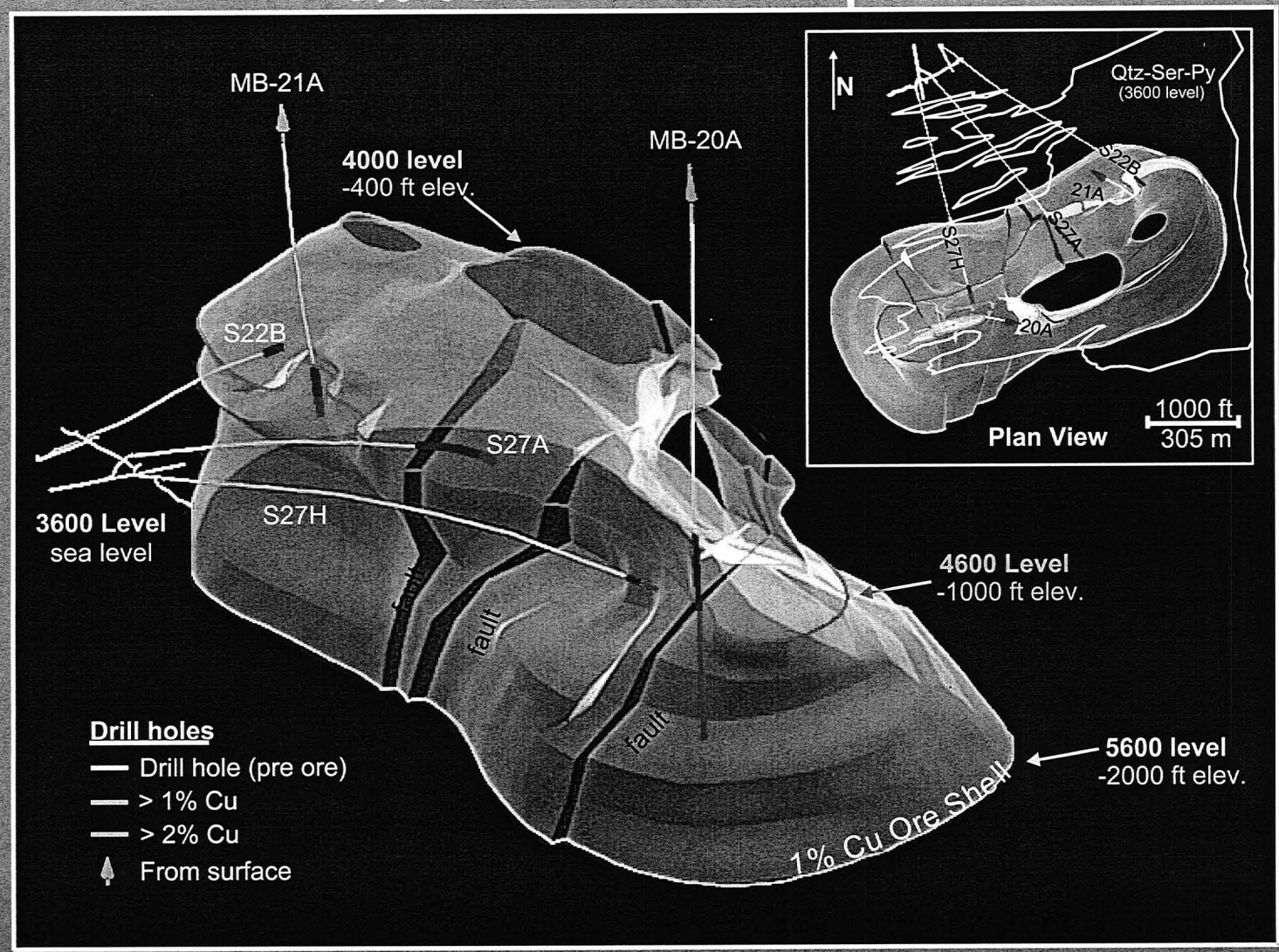
Figure 1

MAGMA PORPHYRY EXPLORATION

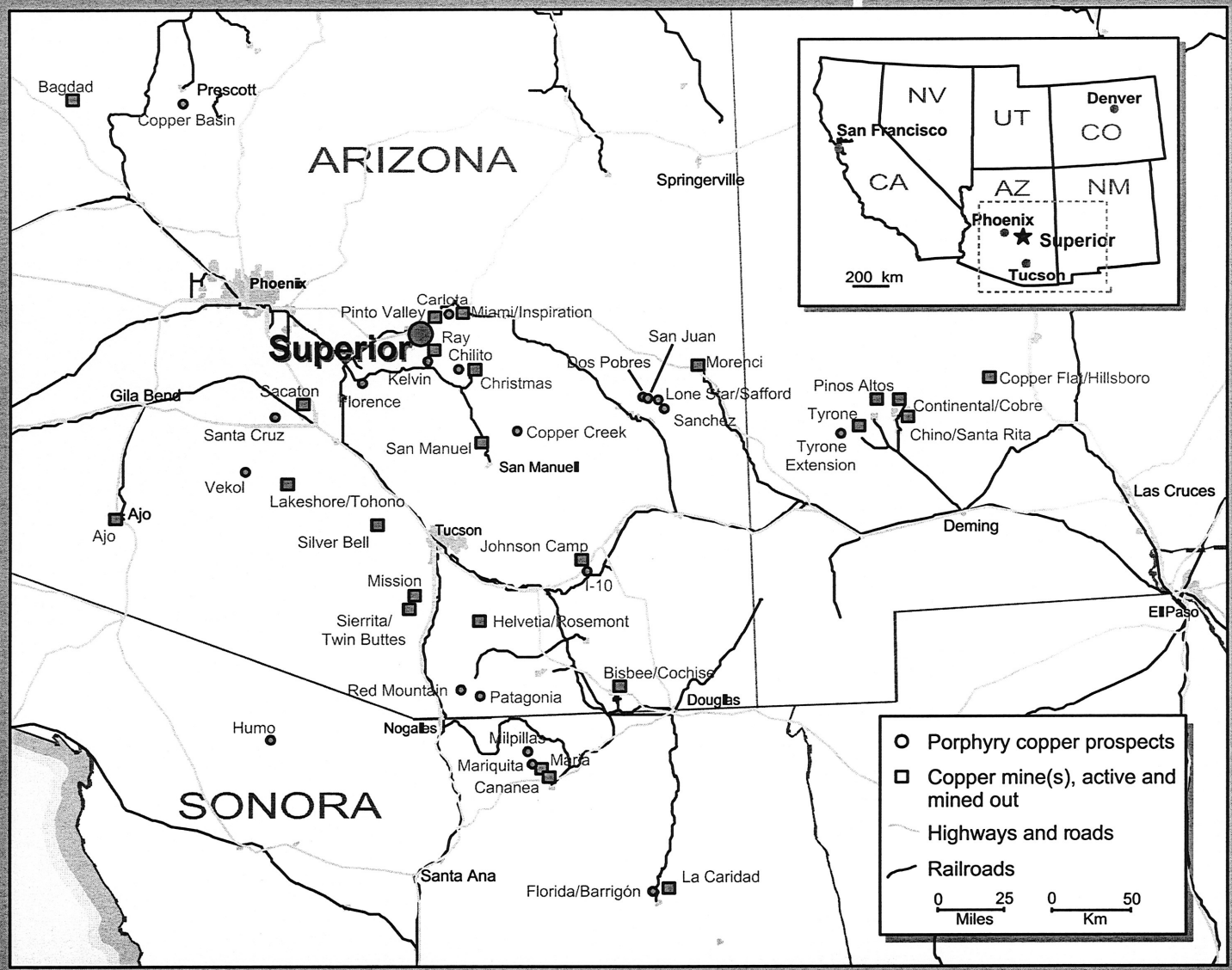


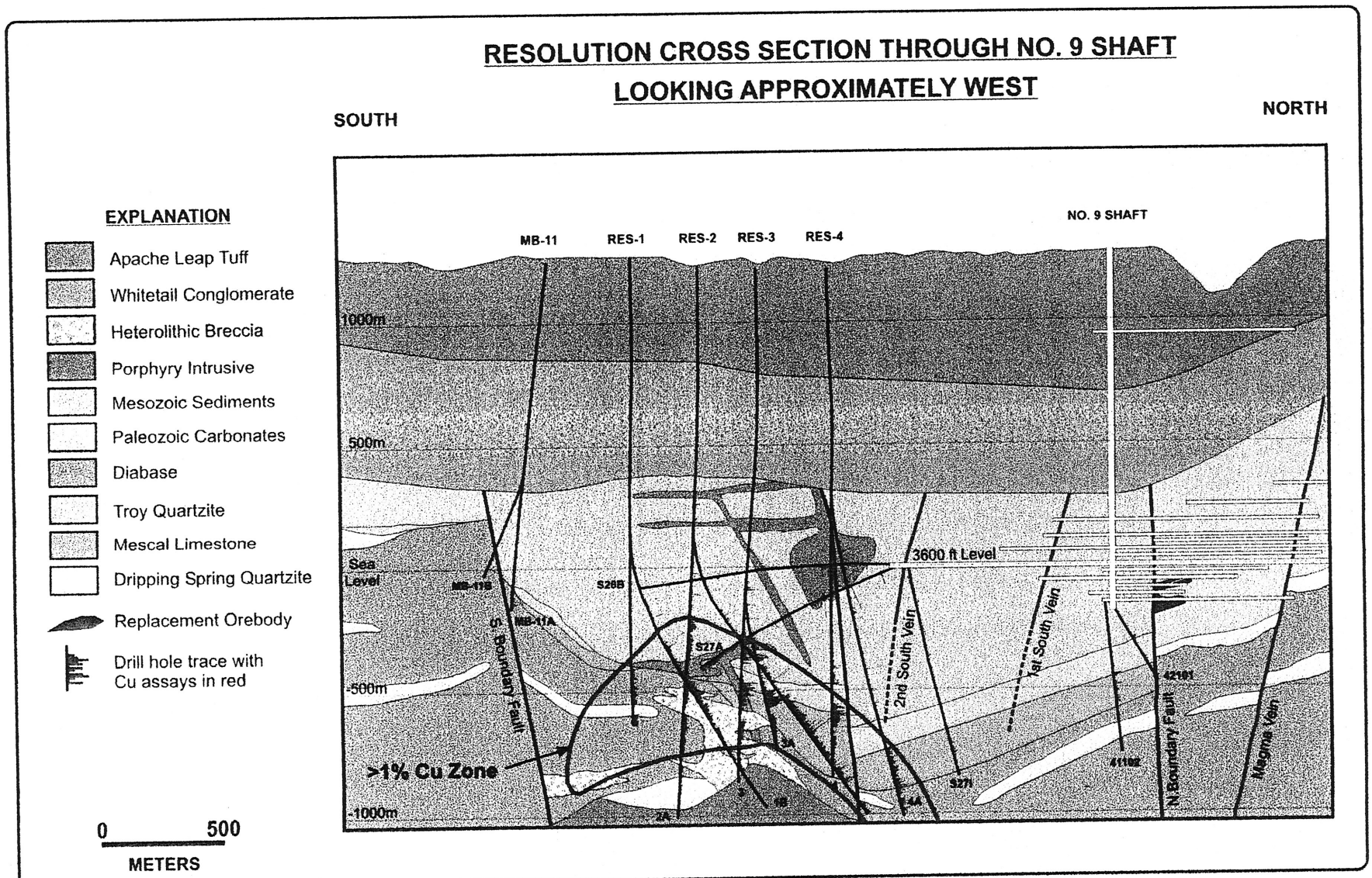
MB-20A

Three-Dimensional Perspective of a Model 1% Cu Grade Envelope



Location Map




RESOLUTION CROSS SECTION THROUGH NO. 9 SHAFT
LOOKING APPROXIMATELY WEST
SOUTH
NORTH
EXPLANATION
Apache Leap Tuff
Whitetail Conglomerate
Heterolithic Breccia
Porphyry Intrusive
Mesozoic Sediments
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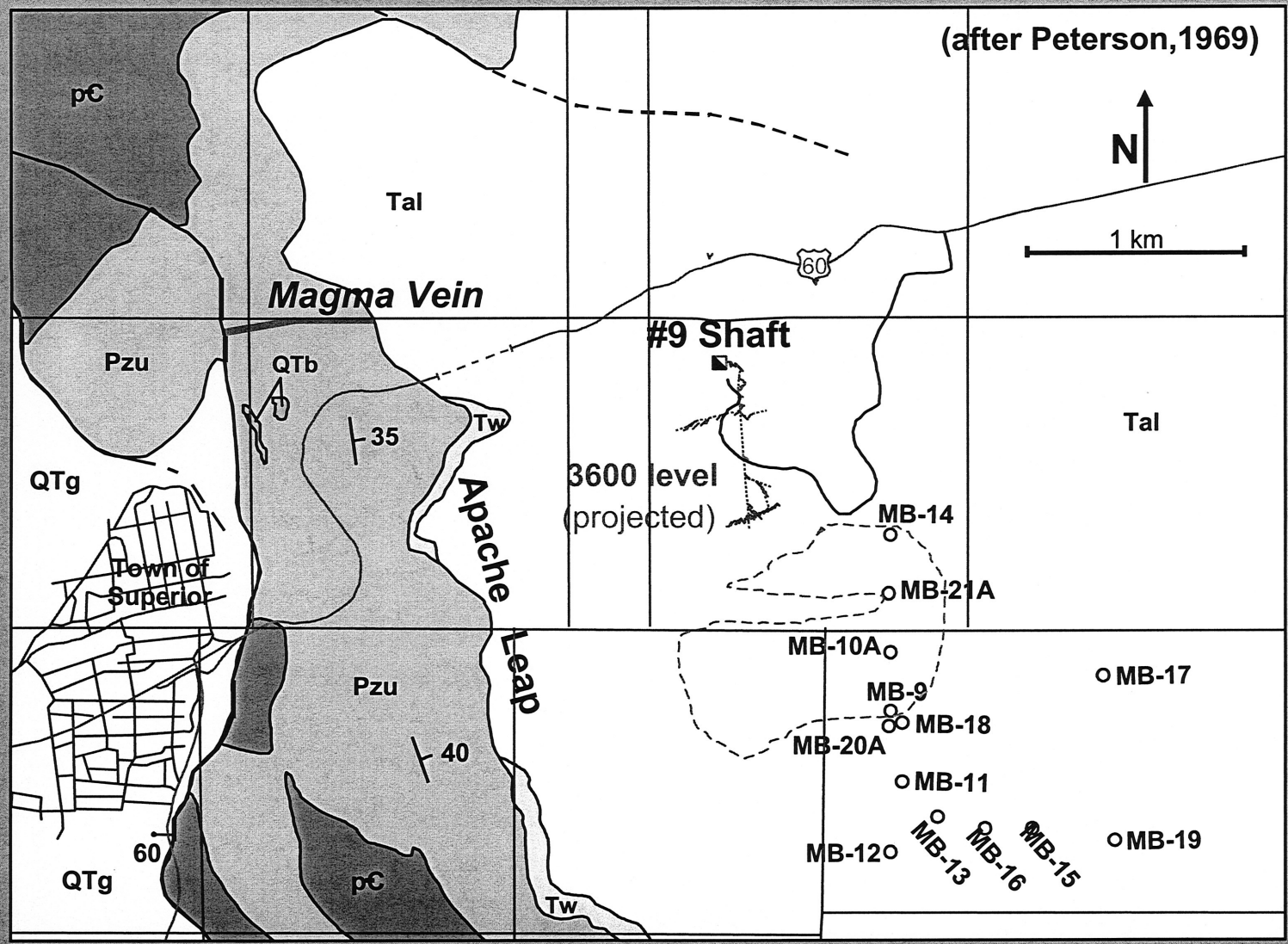
Diabase
Troy Quartzite
Mescal Limestone
Dripping Spring Quartzite
Replacement Orebody
Drill hole trace with Cu assays in red
0
500
METERS
MB-11
RES-1
RES-2
RES-3
RES-4
NO. 9 SHAFT
1000m
500m
Sea Level
-500m
-1000m
3600 ft Level
MB-11B
MB-11A
S26B
S27A
S. Boundary Fault
2nd South Vein
1st South Vein
N. Boundary Fault
Magma Vein
>1% Cu Zone
S27I
41102
42101

Figure 1

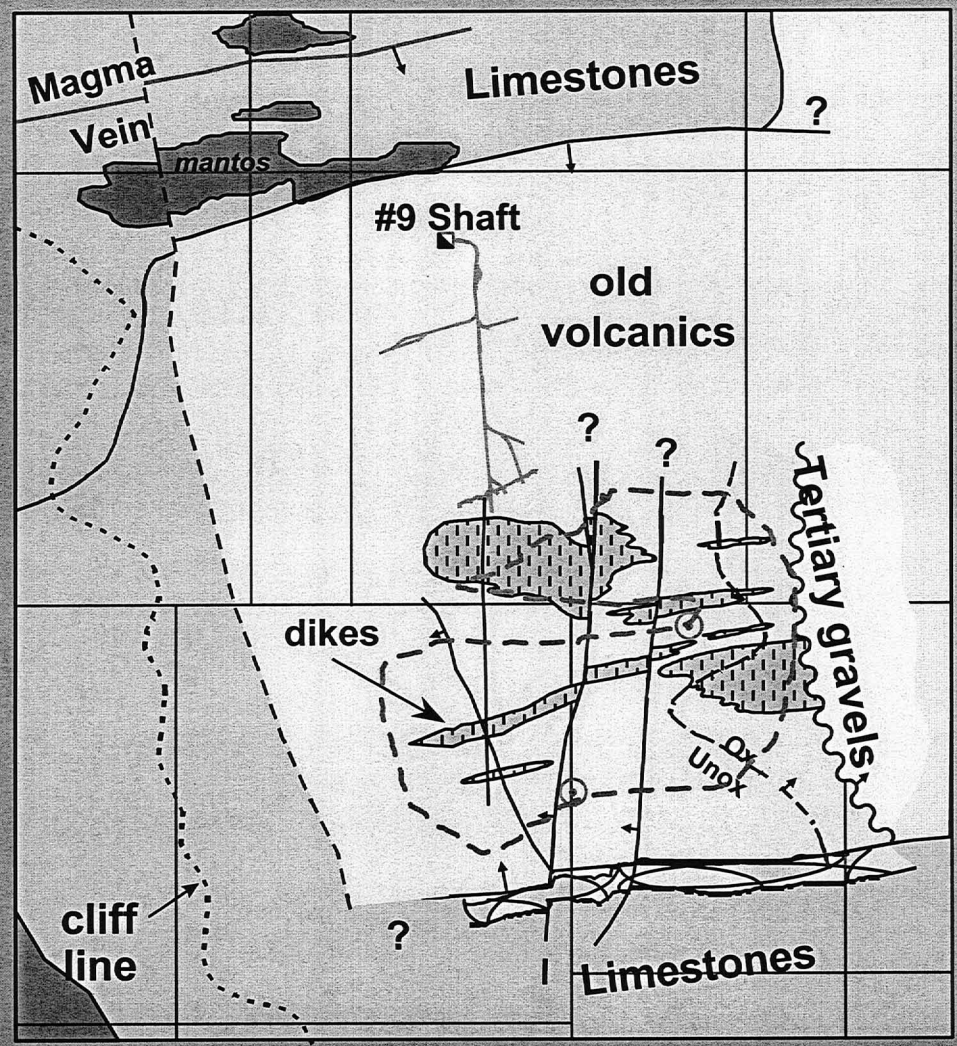
Superior District Surface Geology



Geologic Issues

- **Depth and temperature**
- **Rock mechanics**
- **Water**
- **Continuity of grade**
- **Metallurgical parameters (variable sulfide mineralogy; arsenic)**
- **More Data Needed**

Subsurface Geology, 3600 Level of the Magma Mine (~sea level)



N

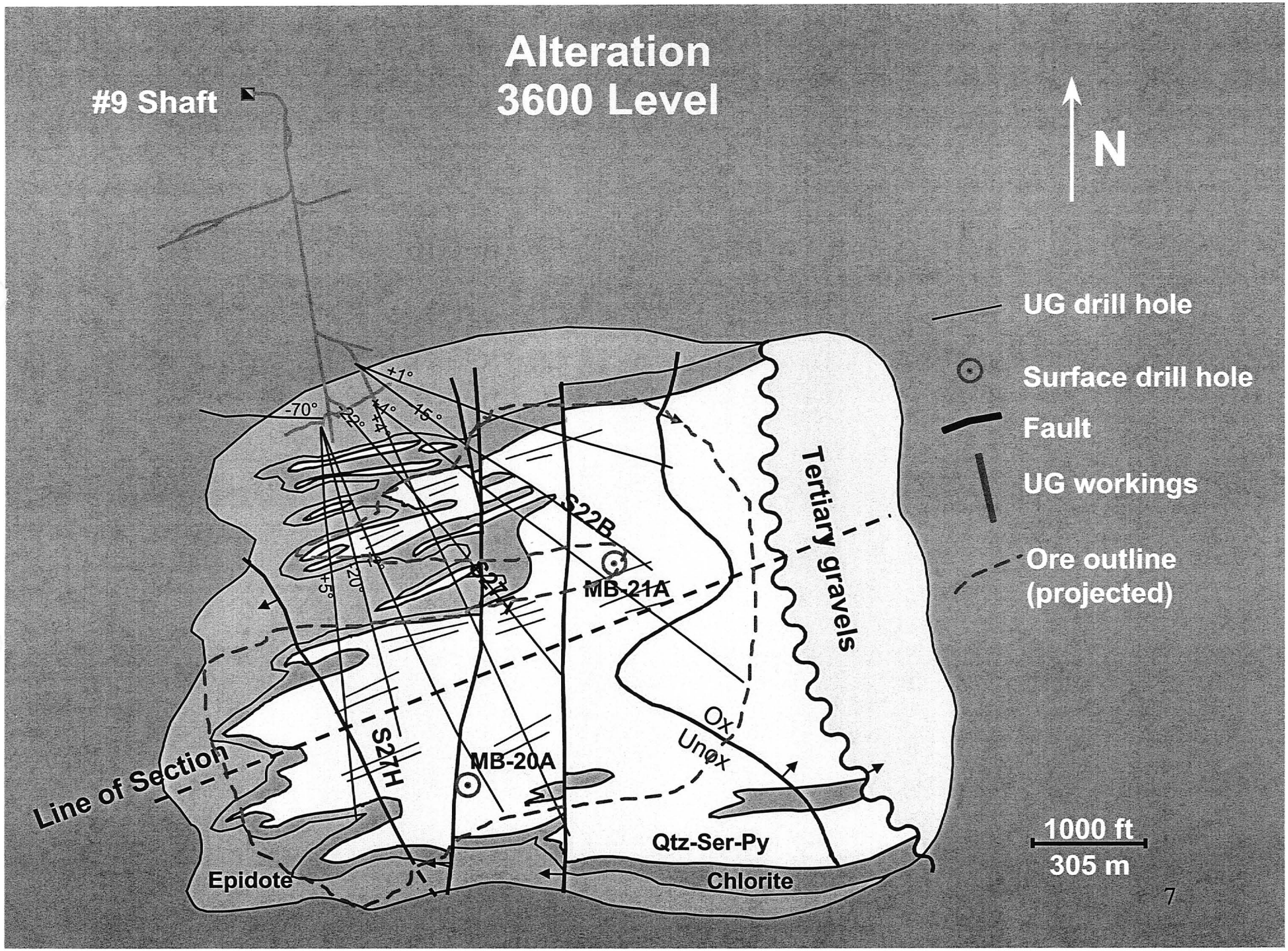
Underground workings

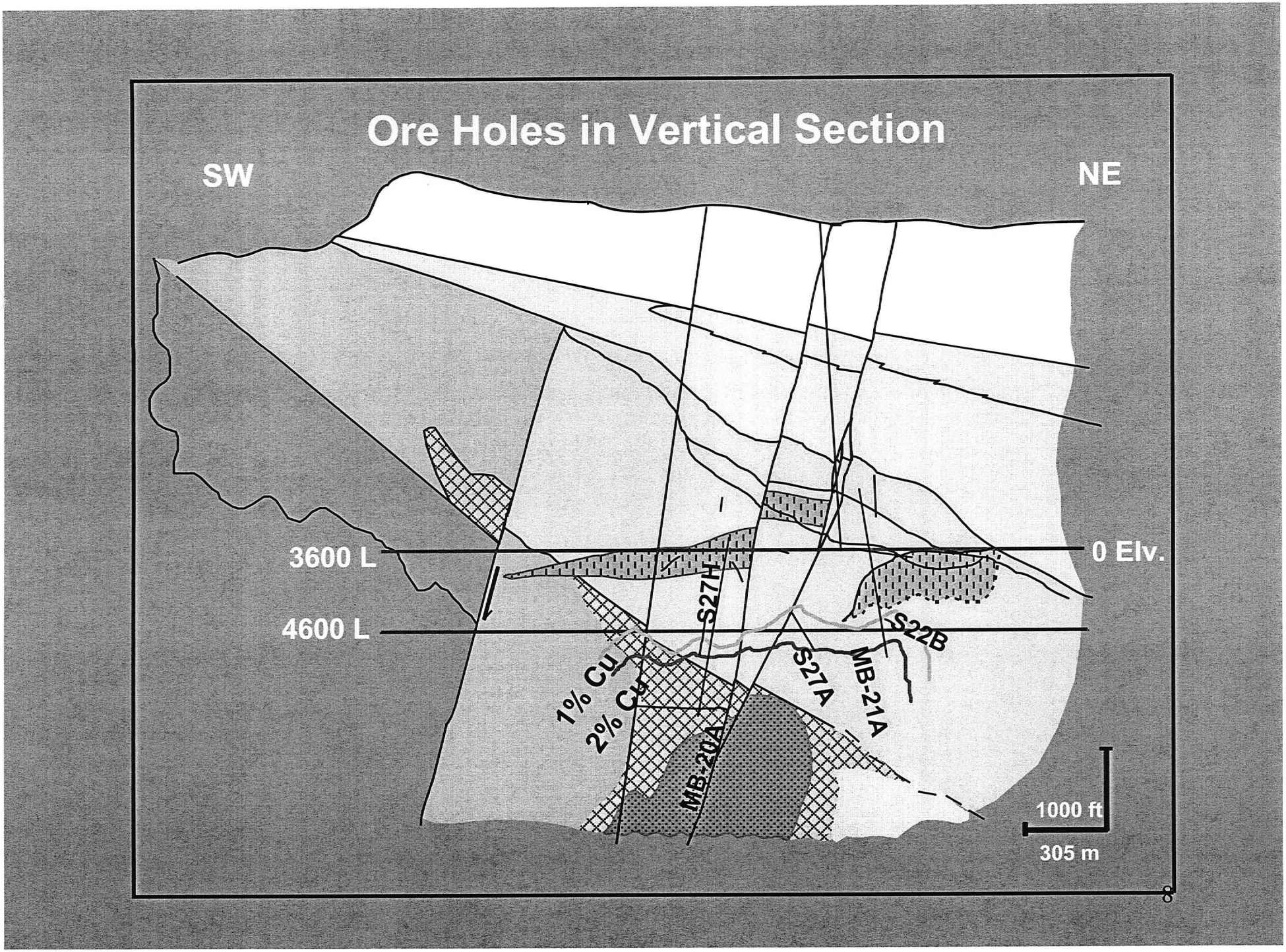
Fault

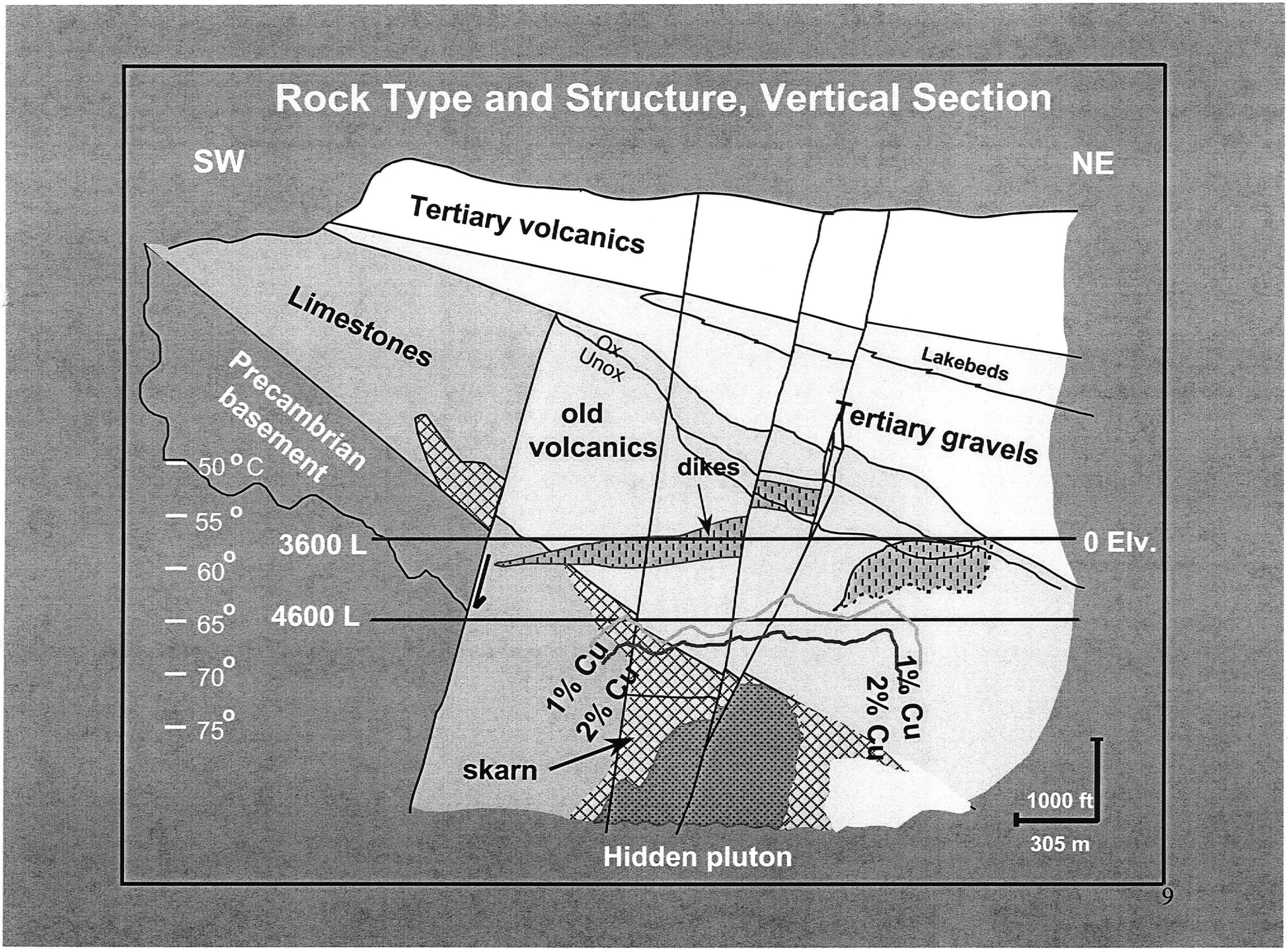
Surface DDH

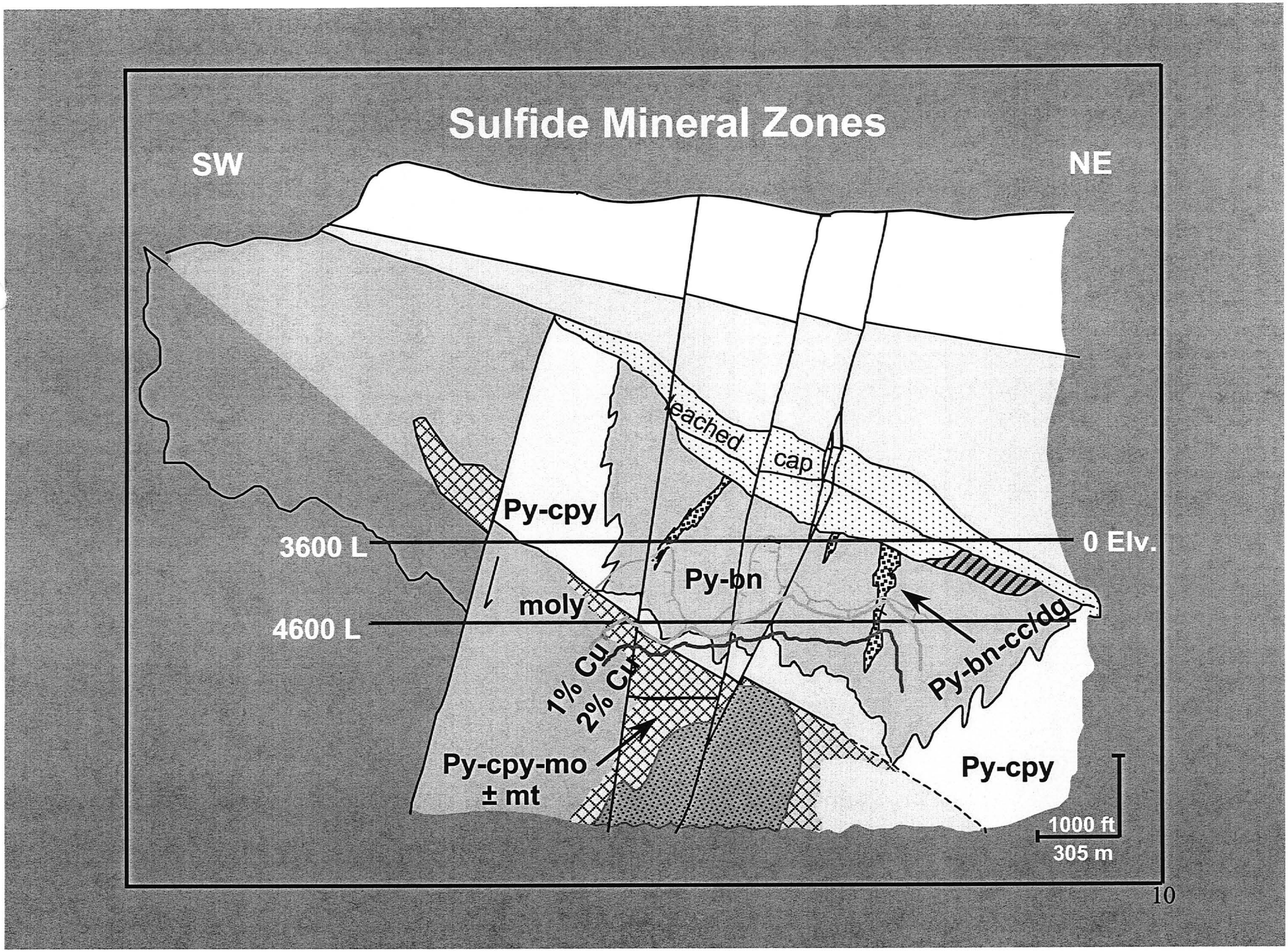
Ore outline (projected)

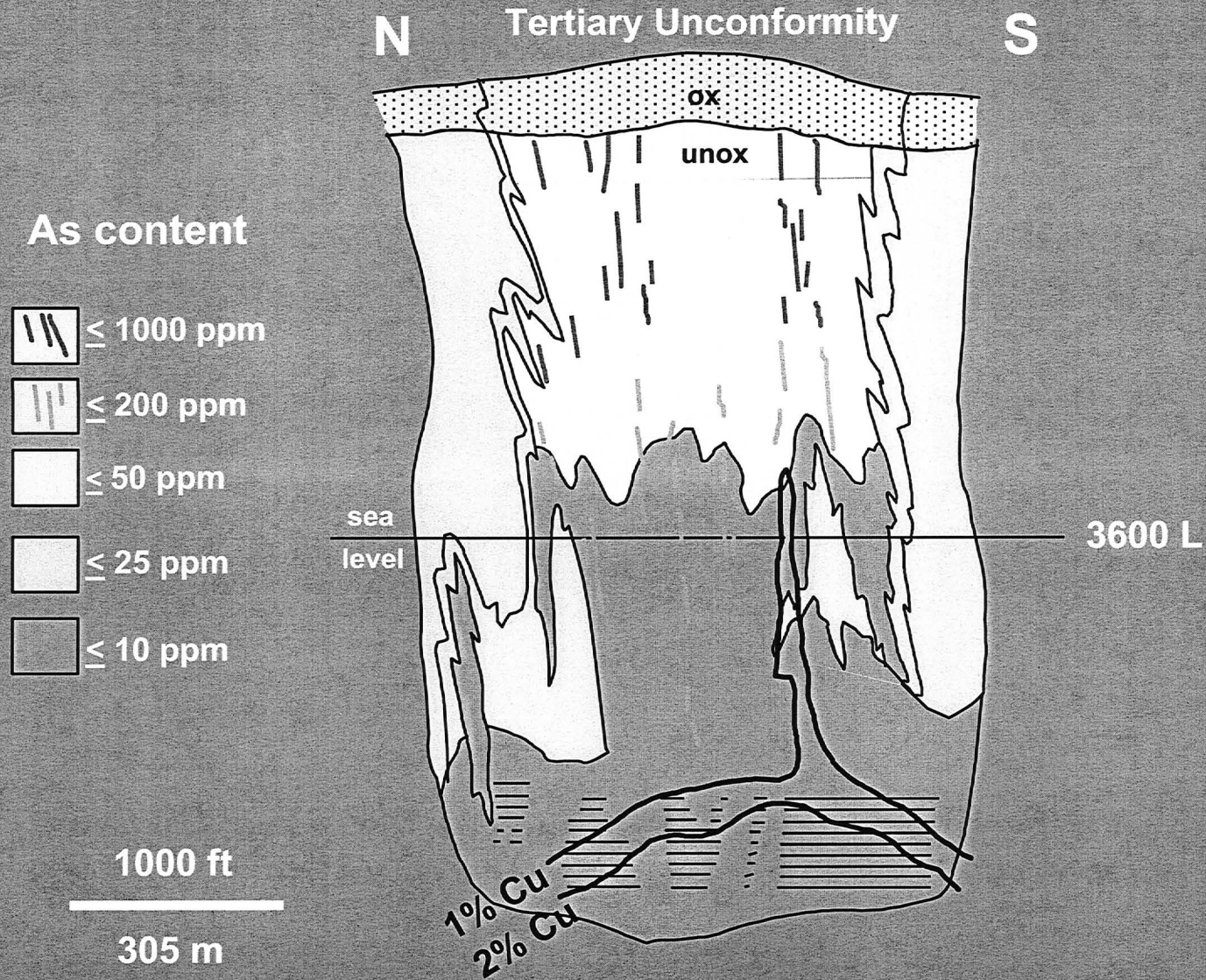
1 km


Alteration
3600 Level
#9 Shaft
N
UG drill hole
Surface drill hole
Fault
UG workings
Ore outline
(projected)
Tertiary gravels
S22B
MB-21A
S21X
S27H
MB-20A
Oxi
Unox
Line of Section
Epidote
Qtz-Ser-Py
Chlorite
1000 ft
305 m
-70°
-22°
+4°
+1°
45°
+5°
+20°


Ore Holes in Vertical Section
SW
NE
3600 L
0 Elv.
4600 L
S27H
S22B
S27A
MB-21A
1% Cu
2% Cu
MB-20A
1000 ft
305 m


Rock Type and Structure, Vertical Section
SW
NE
Tertiary volcanics
Limestones
Precambrian basement
Ox
Unox
old volcanics
Lakebeds
Tertiary gravels
dikes
50 °C
55 °
60°
65°
70°
75°
3600 L
0 Elv.
4600 L
1% Cu
2% Cu
1% Cu
2% Cu
skarn
1000 ft
305 m
Hidden pluton


Sulfide Mineral Zones
SW
NE
Leached cap
Py-cpy
3600 L
0 Elv.
Py-bn
moly
4600 L
1% Cu
2% Cu
Py-bn-cc/dg
Py-cpy-mo
± mt
Py-cpy
1000 ft
305 m



Geochemical Gradients

The Geologic Positives

- Simple structure (entire deposit present)
- Caveable (low anhydrite; favorable strength tests)
- Metallurgically tractable (low As; c.g. cpy; f.g. sulfides Cu-rich; ~90% recovery in bench tests; Ag, Mo credits)
- Big: $\geq$ 90th percentile in deposit size
- Rich: ~99th percentile in deposit grade

Geologic Issues

- Depth and temperature
- Rock mechanics
- Water
- Continuity of grade
- Metallurgical parameters (variable sulfide mineralogy; arsenic)
- More Data Needed

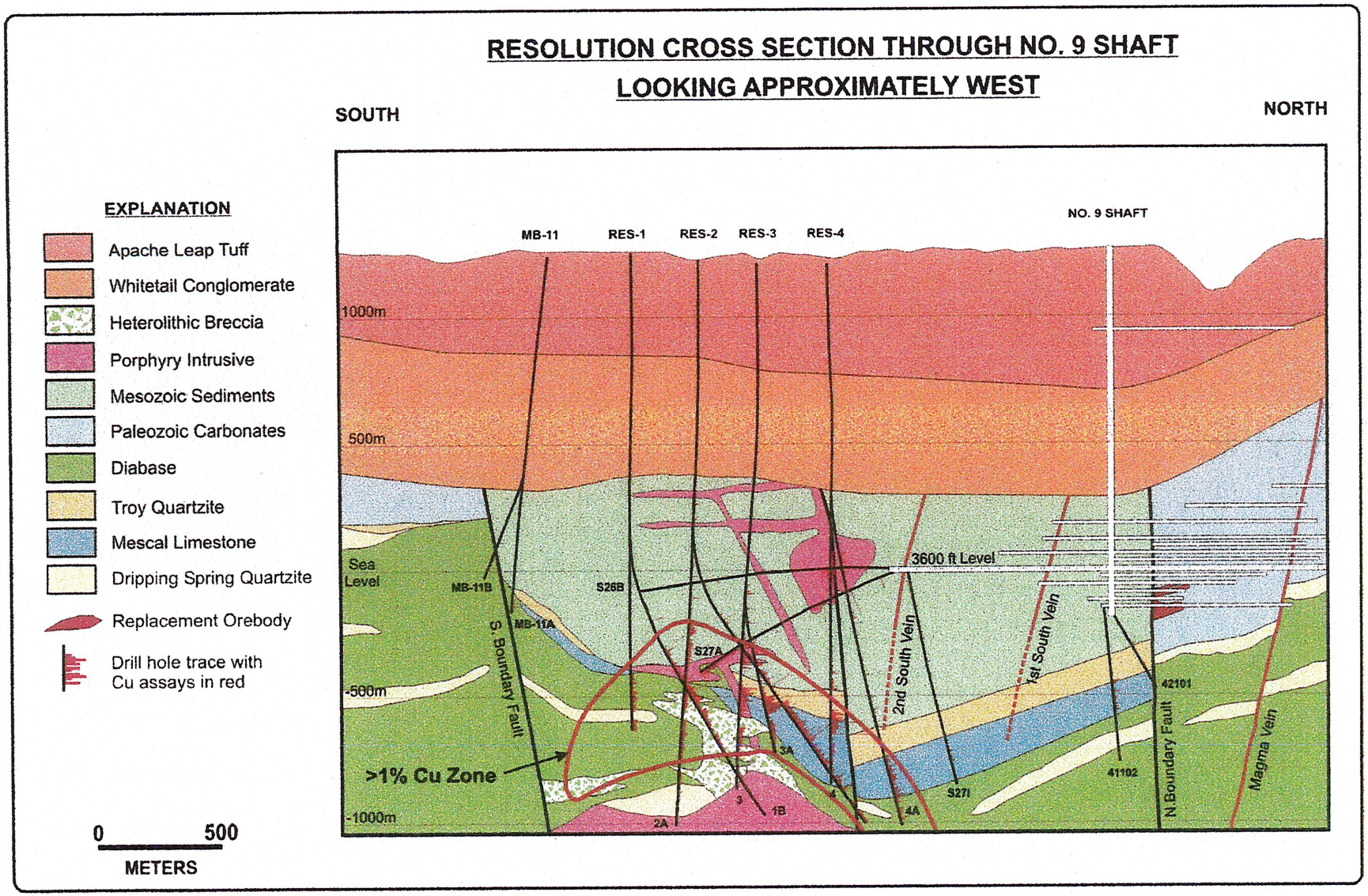
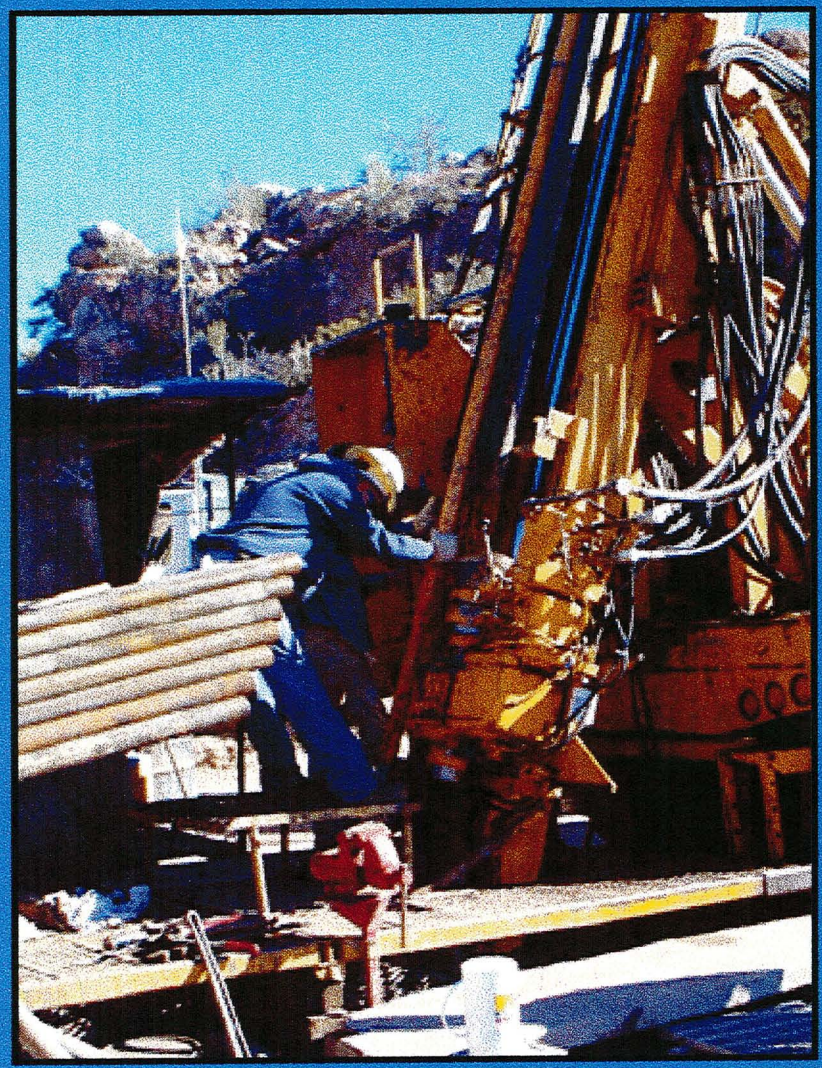

RESOLUTION CROSS SECTION THROUGH NO. 9 SHAFT
LOOKING APPROXIMATELY WEST
SOUTH
NORTH
EXPLANATION
Apache Leap Tuff
Whitetail Conglomerate
Heterolithic Breccia
Porphyry Intrusive
Mesozoic Sediments
Paleozoic Carbonates
Diabase
Troy Quartzite
Mescal Limestone
Dripping Spring Quartzite
Replacement Orebody
Drill hole trace with Cu assays in red
0
500
METERS
MB-11
RES-1
RES-2
RES-3
RES-4
NO. 9 SHAFT
1000m
500m
Sea Level
-500m
-1000m
MB-11B
MB-11A
S26B
S27A
S27I
3600 ft Level
S. Boundary Fault
2nd South Vein
1st South Vein
N.Boundary Fault
Magma Vein
42101
41102
>1% Cu Zone
2A
3
1B
3A
4A

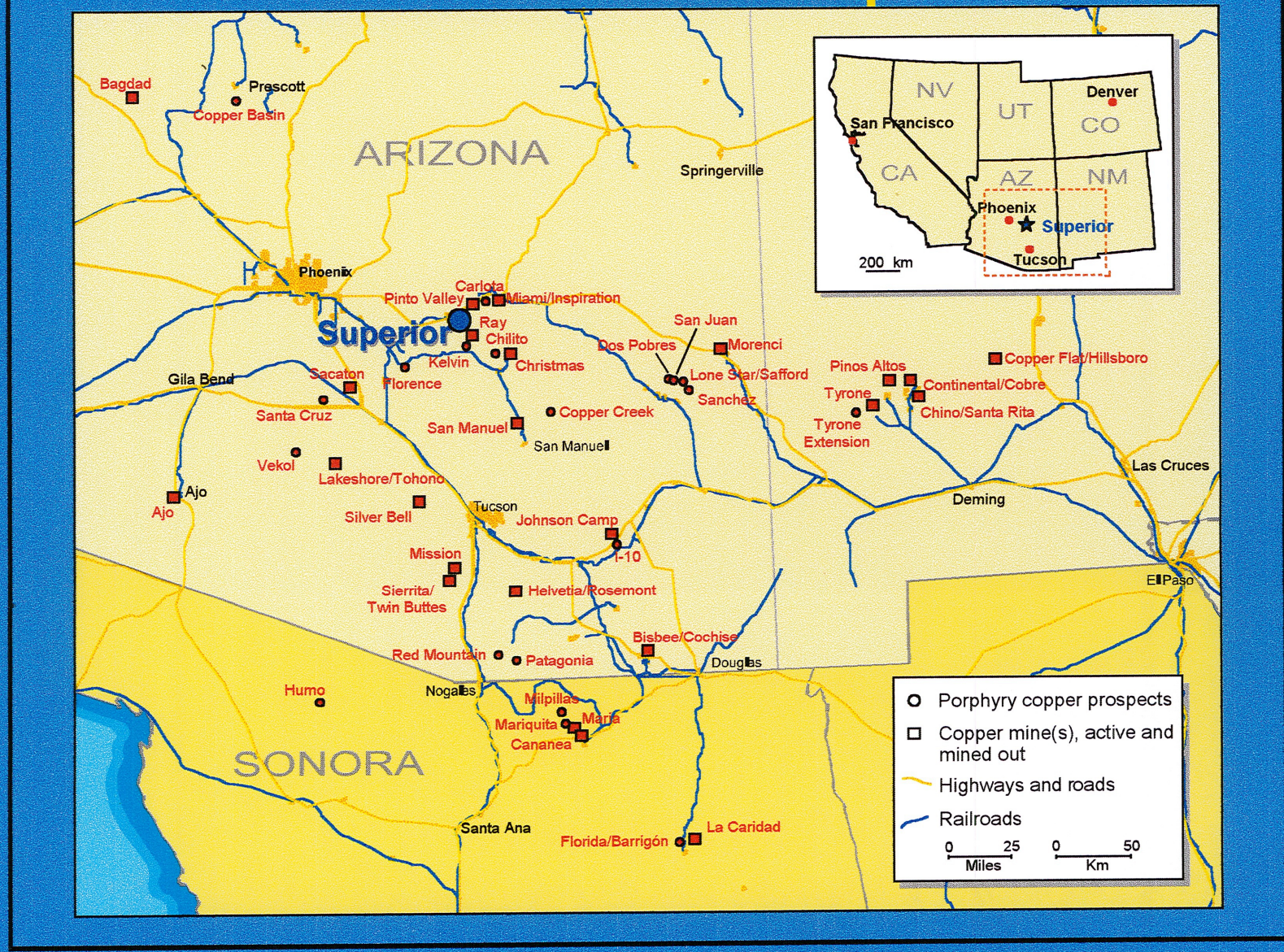
Figure 1

MAGMA PORPHYRY EXPLORATION

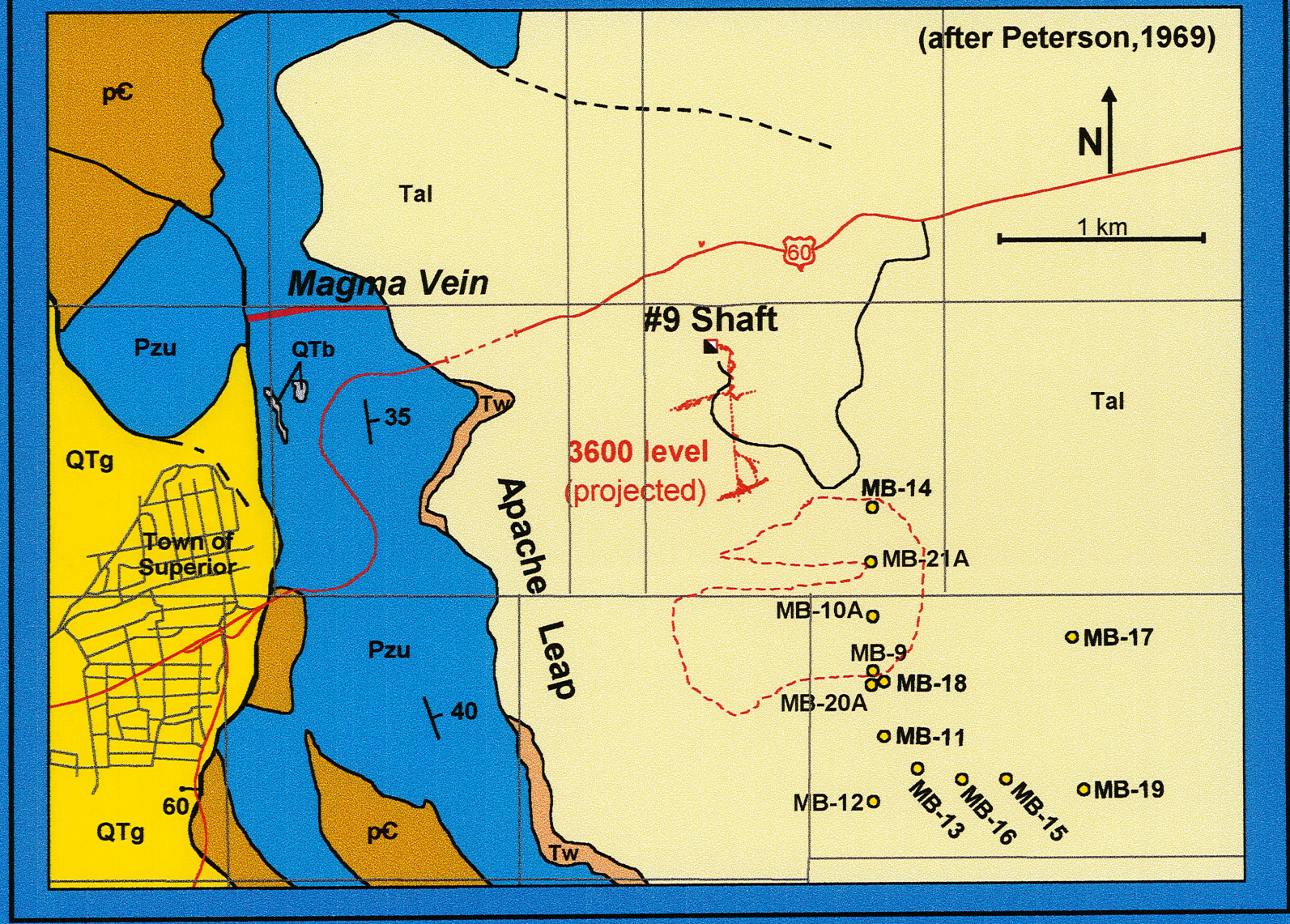


MB-20A

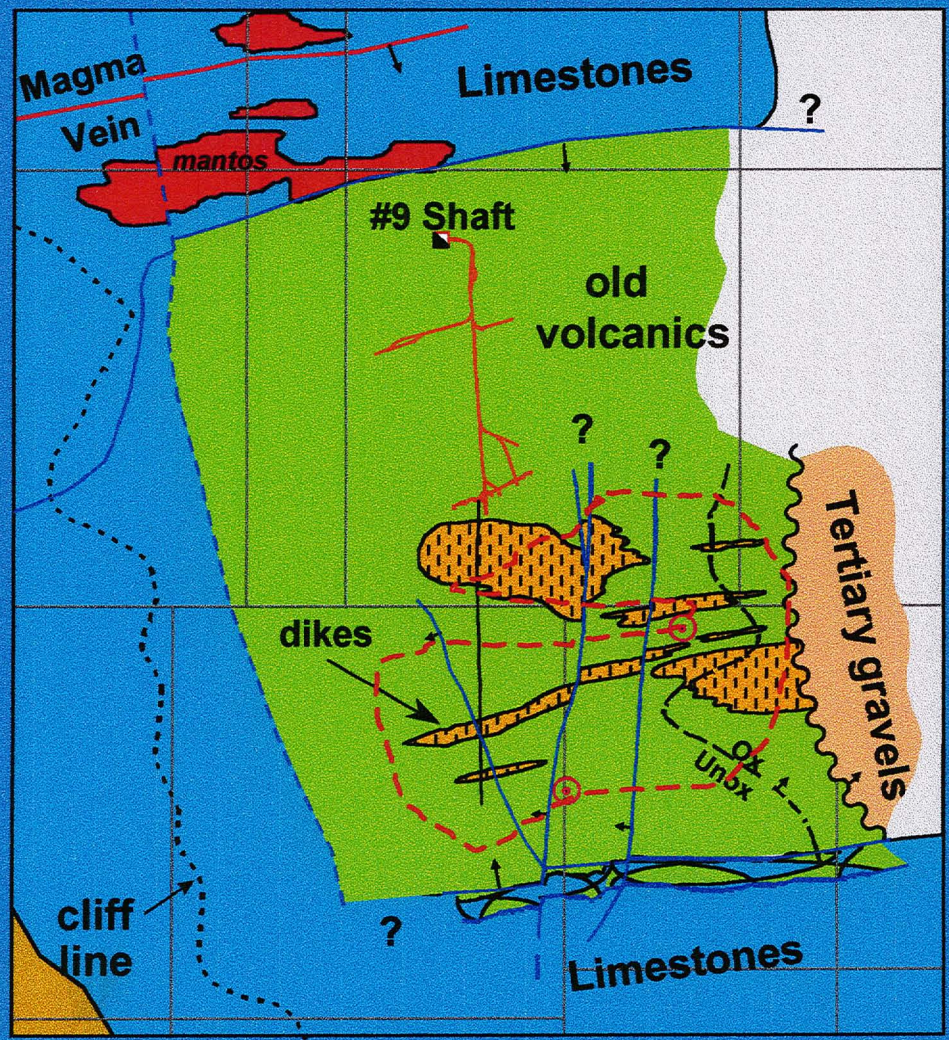
Location Map



Superior District Surface Geology



Subsurface Geology, 3600 Level of the Magma Mine (~sea level)



N

Underground workings

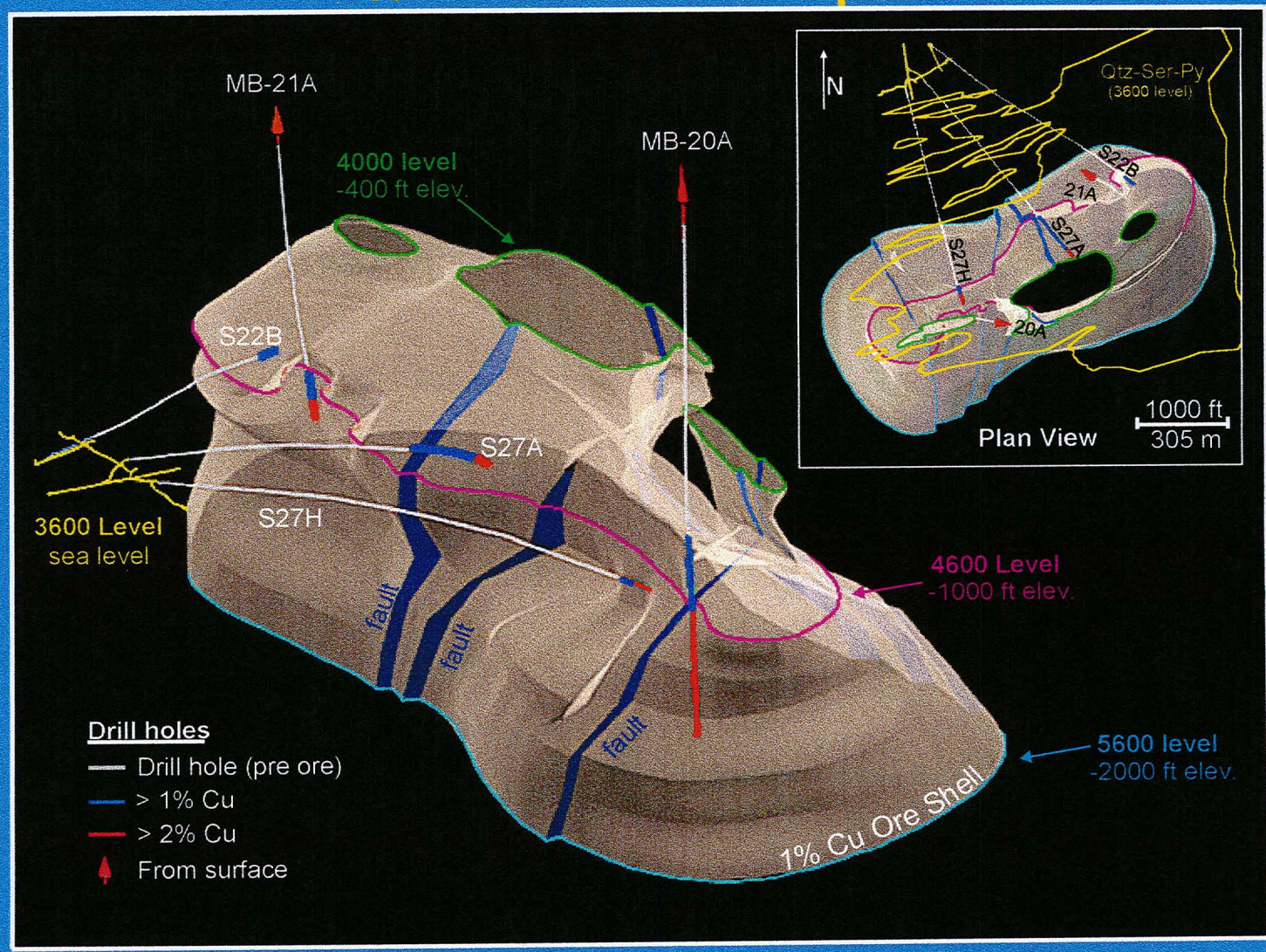
Fault

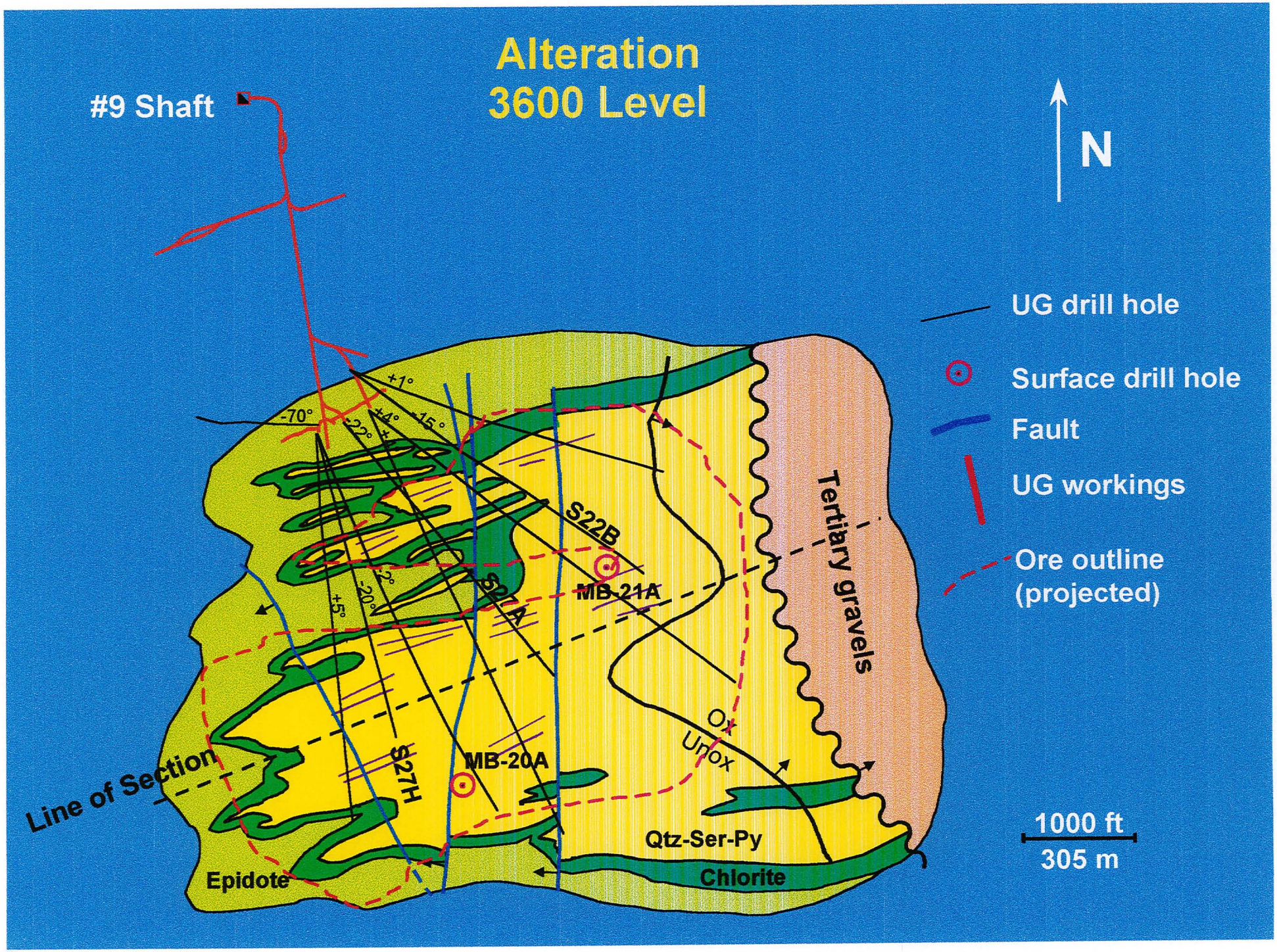
Surface DDH

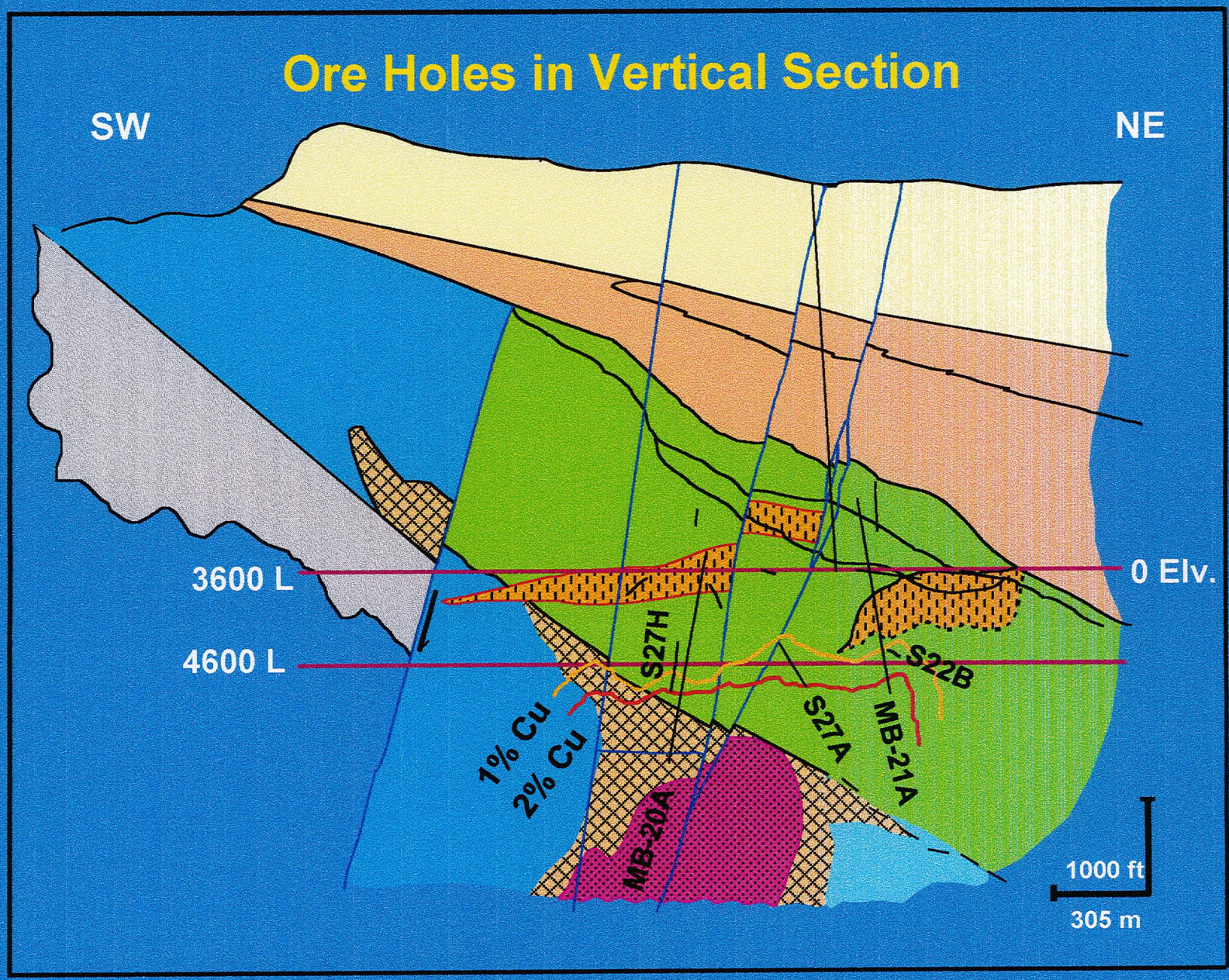
Ore outline (projected)

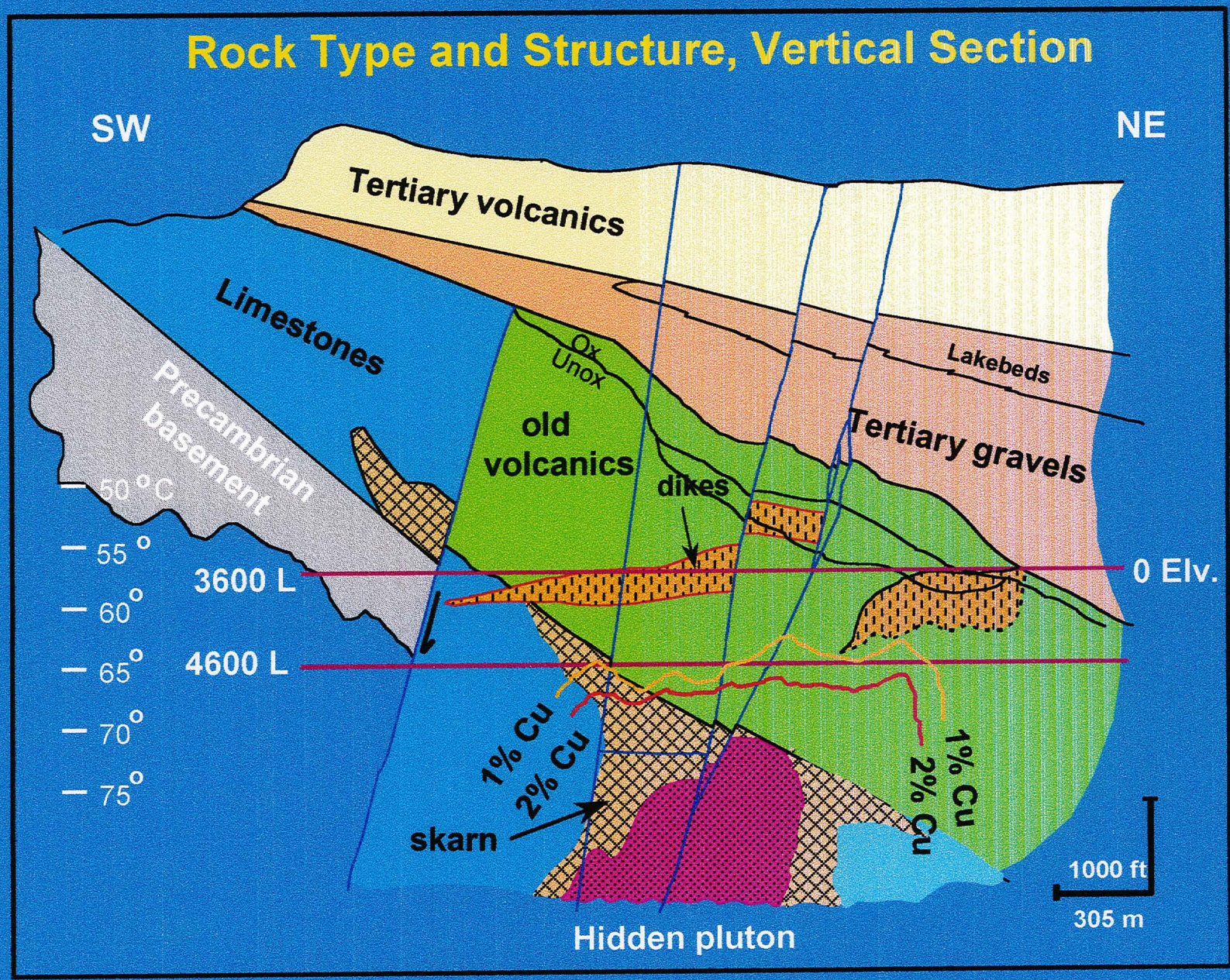
1 km

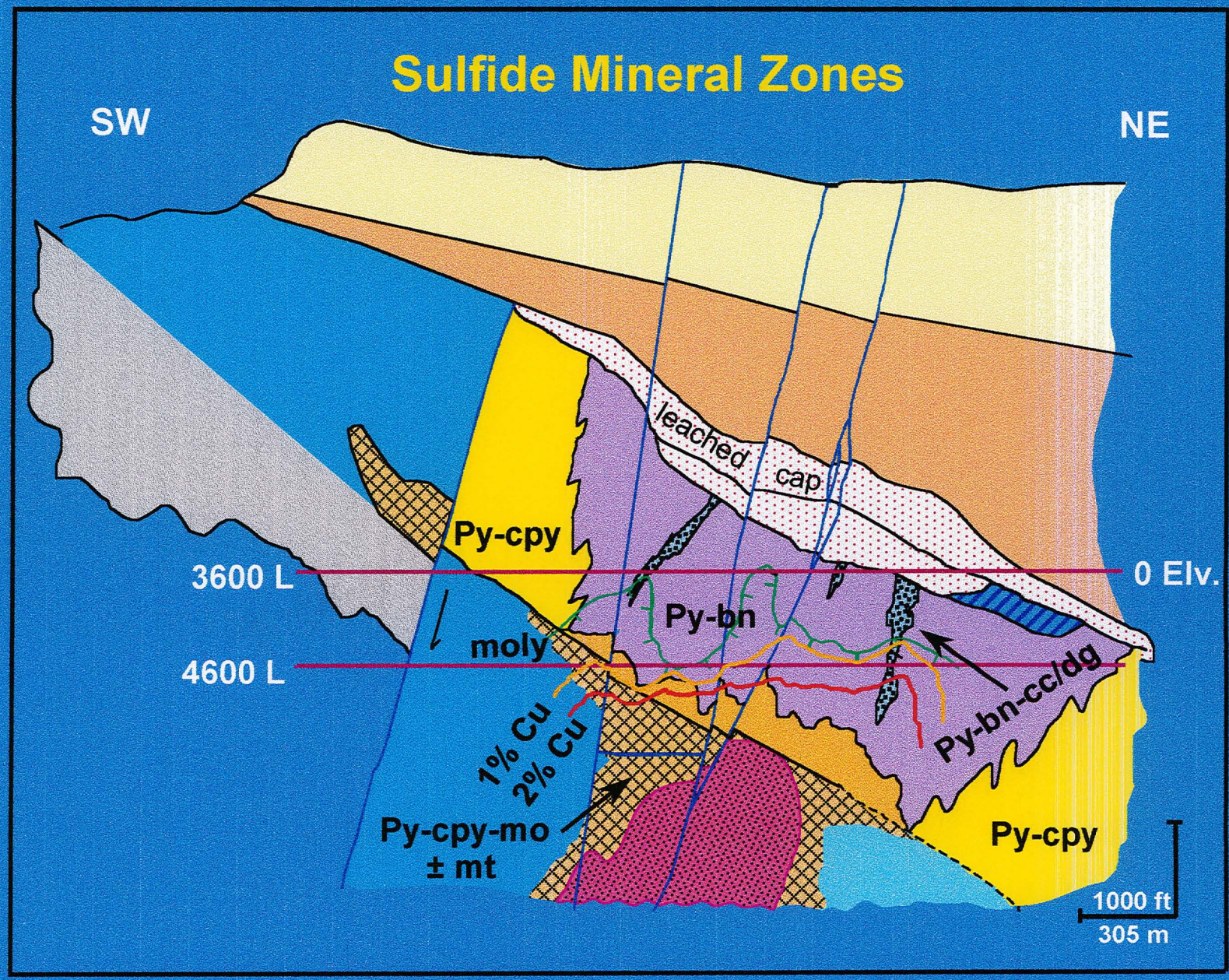
Three-Dimensional Perspective of a Model 1% Cu Grade Envelope

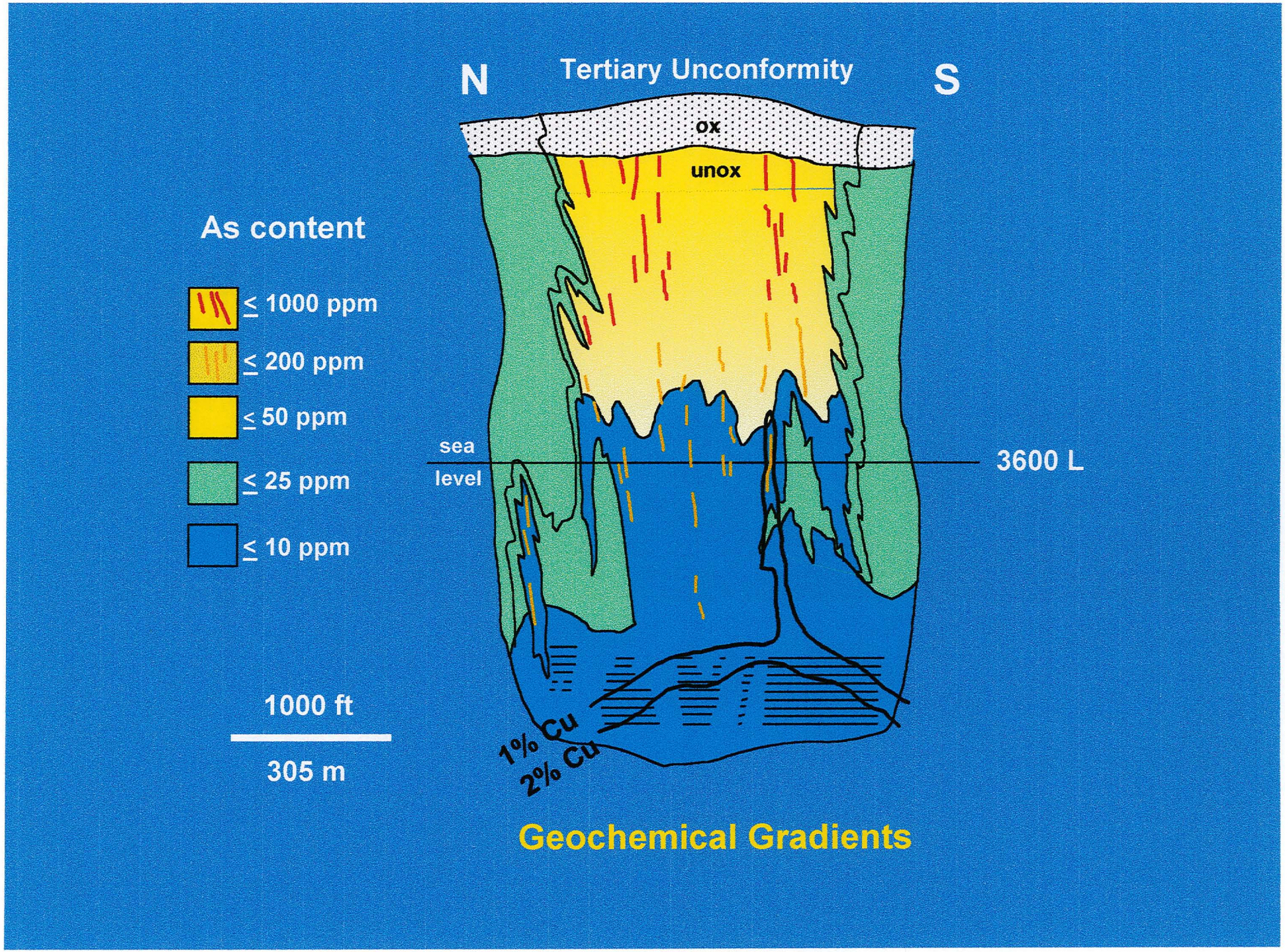



Alteration
3600 Level
#9 Shaft
N
UG drill hole
Surface drill hole
Fault
UG workings
Ore outline
(projected)
Tertiary gravels
S22B
MB-21A
S21A
MB-20A
S27H
Ox
Unox
Qtz-Ser-Py
Chlorite
Epidote
Line of Section
1000 ft
305 m
+1°
-70°
-22°
+4°
-15°
-2°
-20°
+5°


Ore Holes in Vertical Section
SW
NE
3600 L
4600 L
0 Elv.
S27H
S22B
S27A
MB-21A
1% Cu
2% Cu
MB-20A
1000 ft
305 m


Rock Type and Structure, Vertical Section
SW
NE
Tertiary volcanics
Limestones
Precambrian basement
Ox
Unox
old volcanics
dikes
Lakebeds
Tertiary gravels
50 °C
55 °
60°
65°
70°
75°
3600 L
4600 L
0 Elv.
1% Cu
2% Cu
skarn
1% Cu
2% Cu
1000 ft
305 m
Hidden pluton


Sulfide Mineral Zones
SW
NE
leached cap
Py-cpy
3600 L
0 Elv.
Py-bn
moly
4600 L
1% Cu
2% Cu
Py-bn-cc/dg
Py-cpy-mo
± mt
Py-cpy
1000 ft
305 m


N
Tertiary Unconformity
S
ox
unox
As content
≤ 1000 ppm
≤ 200 ppm
≤ 50 ppm
≤ 25 ppm
≤ 10 ppm
sea
level
3600 L
1000 ft
305 m
1% Cu
2% Cu
Geochemical Gradients

The Geologic Positives

- Simple structure (entire deposit present)
- Caveable (low anhydrite; favorable strength tests)
- Metallurgically tractable (low As; c.g. cpy; f.g. sulfides Cu-rich; ~90% recovery in bench tests; Ag, Mo credits)
- Big: $\geq$ 90th percentile in deposit size
- Rich: ~99th percentile in deposit grade

MAGMA PORPHYRY IN PINAL

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Geology of a Major New Porphyry Copper Center in the Superior (Pioneer) District, Arizona

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Abstract

A new porphyry copper deposit has been discovered in the Superior (Pioneer) district of east-central Arizona, lying under thick Tertiary cover approximately 2 km south of the historic Magma vein. The porphyry center was encountered in the course of an exploration drilling campaign conducted from 1992 through 1997, comprising a series of subvertical surface core holes and subhorizontal underground core holes ranging in length from 1,000 to 1,955 m. The system is large, structurally intact, and shows indications of a substantial hypogene mineralized zone that averages between 1.0 and 2.0 percent Cu.

The deposit is hosted by a thick sequence of Cretaceous (?) volcaniclastic and siliciclastic sedimentary rocks. The Mesozoic strata rest disconformably on calcareous units of the uppermost Paleozoic Naco Group and are intruded by an east-northeast–striking swarm of quartz porphyry dikes. The dike swarm is truncated at the basal Tertiary unconformity, under which the Mesozoic section is buried by 600 to 1,200 m of unmineralized overburden composed of the Oligocene-Miocene Whitetail Conglomerate and the Miocene (18.6 Ma) Apache Leap dacite tuff. The attitude of the basal Tertiary beds shows that the porphyry center has been tilted 30° to 35° to the east-northeast.

A broad zone of hydrolytic alteration characterizes the high structural levels in Mesozoic wall rocks. Peripheral propylitic alteration in the volcaniclastic rocks is marked by epidote and chlorite, giving way inwardly to a narrow zone of chlorite-dominant alteration in which epidote is destabilized in favor of smectite clays and carbonate. This chlorite zone corresponds closely to the "intermediate argillic" alteration type of Meyer and Hemley (1967). The propylitic fringe of the system is erratically mineralized by vein-controlled pyrite, sphalerite, and specularite with minor chalcopyrite and galena. Chloritic rocks in the intermediate argillic halo contain pyrite and chalcopyrite. The intermediate argillic alteration mantles an inner zone of pervasive quartz-sericite-pyrite. The sericitic zone is strongly pyritic, with bornite and lesser chalcopyrite. Within sericitically altered rock, pyrite-chalcocite-digenite-bornite veins exhibit centimeters- to meters-wide halos of advanced argillic alteration in which sericite is replaced by kaolin group clays.

The quartz-sericite-pyrite zone is superimposed on earlier potassic alteration that remains preserved at deeper levels. The base of the Mesozoic sequence and shaly beds in the upper Naco Group section are pervaded with secondary biotite. Calcareous rocks in the Naco Group are altered to (1) pyroxene-epidote hornfelses and minor garnet-magnetite skarn, overprinted by (2) actinolite and (3) chlorite-carbonate-clay alteration. Biotitically altered rocks are mineralized by quartz-pyrite-chalcopyrite ± anhydrite veins. Molybdenite is present in an early generation of quartz-rich pyrite ± chalcopyrite veins. Hornfelses and skarn in the Naco Group are strongly mineralized by quartz-poor, chalcopyrite-pyrite-anhydrite veins with chloritic envelopes.

Surface and underground drilling into the deposit has outlined a zone of ≥1.0 percent hypogene Cu that is at least 750 m long by 250 m wide by 300 m high, elongated to the east-northeast. The same volume of rock also averages 0.02 percent Mo and 2 ppm Ag. This zone apexes approximately 300 m below sea level, slightly more than 1.5 km below the ground surface, and remains open in all directions laterally and at depth. Four of the last five drill holes penetrating this zone ended in rock assaying ≥2.0 percent hypogene Cu.

Introduction

THIS PAPER constitutes the first detailed description of the geology, host rocks, structural setting, and alteration systematics of a major new porphyry copper center recently discovered in the American southwest. The deposit augments the Laramide-age porphyry copper cluster of east-central Arizona. It lies within the well-known Superior (Pioneer) district, a base and precious metals camp that has been actively

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