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AN OVERVIEW OF THE WORLD'S PORPHYRY AND OTHER HYDROTHERMAL COPPER & GOLD DEPOSITS AND THEIR DISTRIBUTION.

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Abstract - Hydrothermal copper & gold deposits associated with felsic intrusives, particularly porphyry related and epithermal ores, are found in a series of extensive, narrow, linear metallogenic provinces throughout the world. These are predominantly associated with the great Mesozoic to Cainozoic orogenic belts. Major deposits however, are also found within Palaeozoic orogens, while a few are known from the Precambrian. The style and setting of these deposits is variable and diverse, although many common features emerge from a global comparison.

Contributions on major new discoveries, mines and lesser known important deposits from more remote locations make up this conference. They are equally divided among the four most important of the great orogenic belts that embrace porphyry and other hydrothermal Cu and Au deposits around the world, namely the Cordillera of the Americas, the Asia-Pacific, the Tethyan Belt and Central Asia.

This paper provides a global context to those contributions by discussing and comparing the distribution and characteristics of each of these orogenic belts and their mineral deposits, both geologically and geographically. It also discusses the progress made this century in understanding the porphyry orebodies in particular, and the importance of comparing deposits from around the world to better understand the potential and possibilities for major new discoveries and developments.

Introduction

Hydrothermal copper and gold, particularly porphyry orebodies, are among the most significant in the world from the viewpoint of size and/or grade. They are the basis of some of the world's largest mining operations and are the cornerstone of many of the worlds great mining houses. As such, they are an important target for many companies.

The aim of this conference is to provide a global overview of new developments relating to these deposits around the world, looking at the common factors and the contrasts that are emerging to provide a better appreciation of the exploration and development possibilities.

To this end, the conference includes papers on major new discoveries, new mines brought into production and newly emerging provinces, but also on the more established great copper and gold deposits of central and southern Asia and eastern Europe, for which, until recently, information has been less accessible. The main emphasis is on case histories of discovery and on descriptive geology, supported by economic and commercial detail, directed principally towards, and presented by, industry geologists.

Although we have learned a lot about these deposits, our understanding is far from complete. It is hoped that this conference will incrementally advance that understanding.

Historical Understanding of Porphyry & Other Hydrothermal Deposits

The mining history of porphyry copper and gold orebodies, and to a lesser degree of bulk gold deposits, commenced more of less with the 20th century. In the latter years of the 19th century a number of organisations around the world entertained the concept of bulk mining low grade ores, mainly in response to declining grades as the limited high grade tonnages remaining struggled to accommodate world demand.

The first successful bulk mining operation however, was by Utah Copper in 1905 at Bingham Canyon in the US. This was not a reflection of the discovery of a deposit, but rather the engineering ability to mine on a large scale at low cost, and simultaneously to metallurgically recover the copper at the same rate by the flotation process (Gilmour, et. al. 1995), which had only recently been developed in Australia.

Within 10 to 15 years, several other famous porphyry copper deposits were successfully brought into production with grades of 1 to 2% Cu. Many of them, like Bingham Canyon, are still operating today. Over the next 50 years around 20 significant mines recognised as porphyry copper and copper-molybdenum deposits were developed, all within the US "South-west" and in northern Chile and neighbouring southern Peru. With the exception of Bingham Canyon, none were significant gold producers. Many were only economic on the basis of their oxide caps or supergene blankets, developed over low grade (0.25 to 0.5% Cu) primary mineralisation (Gilmour, et. al. 1995).

Right up to the 1960's there was an acceptance by many, that porphyry copper deposits were restricted to Laramide age (late Cretaceous to early Tertiary) porphyritic texture "granitic" intrusive associations, and were localised in the US "South-west" and northern Chile to southern Peru, and were Cu-Mo orebodies (Gilmour, et. al. 1995). All were within continental and continent margin settings.

In the meantime deposits, not then recognised as porphyry systems, were being discovered and mined elsewhere in the world. These included the gold and gold-copper ores of the Baguio and Lepanto-Mankayan districts in the Philippines, which commenced operation in the mid 1930's, but were associated with more intermediate intrusives believed to be late Tertiary in age. During the same period the great Central Asian Palaeozoic deposits of the Soviet Union were outlined, of which the outside world new little. Both of these examples had little influence on thinking on porphyry systems, as they were precluded from the knowledge base.

During the 1950's and 60's however, with political instability and uncertainty growing in Africa, the other great copper producing region, new sources of copper were sought. As a consequence, the focus began to broaden and spread away from the Americas, with exploration for porphyry copper mineralisation commencing both in Australia and in Canada, while the recognition of the nature of the deposits in the Philippines spurred acquisition and exploration there. Most of the Philippines deposits did not have the tonnage or grade of the classic deposits, were molybdenum poor and gold rich, and were spatially associated with epithermal gold mineralisation. The exceptions included the important Atlas and Sipalay Cu-Mo orebodies which were broad analogues of the "South-west" US deposits.

Exploration for porphyry copper mineralisation, based on an Arizona model had commenced in Australia in the 1950's with the sub-economic Moonmera Cu-Mo deposit being identified in 1961 (Whitcher, 1975). As part of that program, the Philippine deposits were visited, leading to the recognition of the similarity in the setting of the latter to the geological terranes of the New Guinea archipelago. This in turn led directly to the discovery in 1964 of the giant

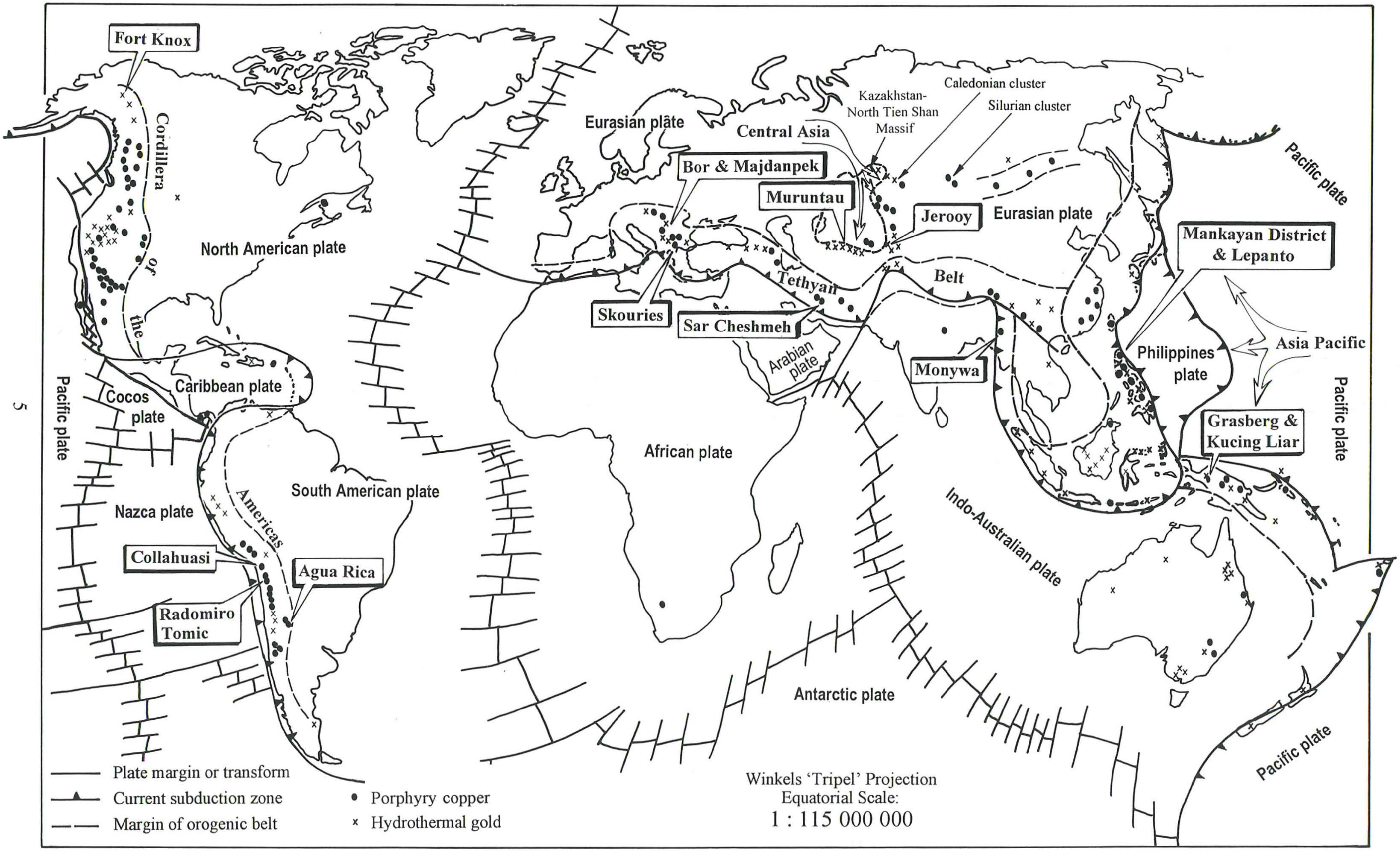

Fig. 1 Distribution of the World's major porphyry copper & hydrothermal gold deposits, showing those covered by the papers of this volume.

Panguna porphyry Cu-Au orebody on Bougainville Island, surrounding the old Kupei alluvial gold and Panguna gold-copper vein workings of the 1930's (Baumer & Fraser, 1985).

The discovery of Panguna, the first world class deposit in the South-east Asian and Australasian region, and its production commencement in 1972, catalysed the wave of exploration that culminated in the discoveries of the great Cu-Au and Au orebodies of Papua New Guinea, Indonesia and the Philippines up to recent times. These mostly younger, late Tertiary to Quaternary deposits in a new region, in an island arc environment, with a more intermediate host rock association, with different mineralisation styles and alteration patterns to the classic deposits of the Americas, high grade hypogene cores and appreciable gold, widened the scope and understanding of porphyry systems enormously (Andrew, 1995).

Meanwhile in Canada, serious exploration for porphyry deposits had begun in the 1950's, particularly in British Columbia, leading to the discovery of a series of deposits such as those of the Highland Valley, Brenda and Island Copper (Sutherland Brown, 1976). These mines were developed in the early 1960's through to the 1970's, and were based on hypogene ore grades alone, without oxide or supergene enrichment caps, and in yet another setting, a series of accretionary terranes, associated with mid to late Mesozoic intrusives and volcanic piles (Mustard, 1976). Later work would emphasise their similarity to the island arc setting deposits of the Asia-Pacific. The porphyry-skarn orebody at Gaspé (Quebec), associated with Devonian intrusives of the Appalachian orogenic belt, had been mined since the early 1950's, but was not recognised as a porphyry deposit until the 1960's (Gilmour, 1982).

During the same period, exploration was filling the gaps between the US and Peru, with major discoveries in Mexico and elsewhere in Central America, as well as the Carribean Arc. Starting in 1966, investigations around ancient workings in Iran outlined the great Sar Cheshmeh copper-gold orebody of Tertiary age within the Tethyan Belt (Waterman & Hamilton, 1975). More recently, significant porphyry deposits have been outlined to the east in Pakistan.

A series of porphyry copper-gold deposits, associated with high sulphidation gold and massive sulphide enargite deposits were developed in areas of ancient workings in the Balkans, in Serbia, Macedonia, Bulgaria and Turkey in particular, from 1960 to the present, associated with late Cretaceous intrusives (Jankovic, 1980) of the Tethyan Belt in Europe.

In parallel, from the late 1920's to the late 1980's exploration and development of copper and gold resources was being undertaken in the Soviet Union to support centrally planned industrialisation programs. While many of the deposits delineated may not have been economic under free market conditions, the better do have very large tonnages of significant grade. A series of great porphyry Cu-Au and Cu-Mo deposits as well as hydrothermal gold orebodies were discovered in a number of regions. Little was known of them beyond the Iron Curtain, nor were they necessarily equated with the great porphyry deposits of the world by those who worked on them, until perhaps the late 1960's. It is only recently that knowledge has filtered out and had some influence on our thinking.

These included the copper and gold deposits in the Soviet sections of the Tethyan Belt, specifically within the Caucasus, between Iran and the Turkey. In Central Asia another great belt of porphyry copper-gold deposits was outlined in a late Palaeozoic orogen in Uzbekistan and Kazakhstan, associated with a belt of large hydrothermal gold deposits. Sub-economic occurrences were located along the mid to late Palaeozoic orogenic belt of the Urals in Russia. Other strings of prospects and exploited deposits of Silurian and Cambrian (Caledonian) age are also found in central Siberia of southern Russia. Further east a metallogenic province embracing early to mid Mesozoic deposits runs east-west across southern Russia, Mongolia and north-eastern China.

In China, exploration has detected a string of porphyry deposits in Tibet associated with Tertiary intrusives of the Tethyan Belt. Further to the east in south-eastern China, on the Asia-Pacific rim, major deposits such as Dexing are associated with Mesozoic intrusives.

A large low grade Proterozoic deposit that may be amenable to SX-EW treatment was outlined at Haib in southern Namibia in the 1970's, while more recently it has been suggested that the large Proterozoic quartz-vein network at Malanjkand in India could have porphyry affinities. Other Precambrian porphyry style accumulations are known, although none are of economic significance.

Having superficially outlined the history of the discovery and development of hydrothermal copper and copper-gold deposits, particularly those of porphyry affinity, the remainder of this paper will be devoted to the distribution and occurrence of such deposits around the world under the heading of the main orogenic belts and regions in which they occur.

Asia Pacific

In the context of this conference, the Asia-Pacific is restricted to the western margin of the Pacific Basin, with the most important deposits being within the South East Asian Archipelago. In addition however, porphyry style mineralisation and hydrothermal gold deposits are also found to the south within Australia, to the south-east in Fiji and New Zealand, and as far north as the Kamchatka Peninsular in the Russian Far East.

Deposits within the South East Asian Archipelago are distributed within the island arcs around the inboard margins of the Eurasian plate (see Fig. 1), where it is in collision with the:

- Indo-Australian plate to the west and south in Myanma and along the south-west coast of Sumatra, Java and Sumbawa in Indonesia, defining the Sunda-Banda Arc;
- Pacific and Philippine Plates to the east in sections of Indonesia, the Philippines, Taiwan and south-east China, the Japanese islands and north to the Kamchatka Peninsula.

In addition, mineralisation and major ore deposits are also found:

- Inboard of the north-eastern margin of the Indo-Australian Plate where it is in collision with the Pacific Plate in Irian Jaya (Indonesia), the main island of Papua New Guinea, through Bougainville and the Solomons to Fiji, and south to New Zealand
- Associated with arcs developed near the sutures between long thin terranes now accreted within the south-eastern sections of the Eurasian Plate, particularly through Kalimantan and Sulawesi and Halmahera in Indonesia (Carlile & Mitchell, 1994).

Within Australia, mineralisation is associated with an older series of regimes during the Ordovician and Permo-Carboniferous in particular, to the Triassic.

Both major porphyry copper-gold and large hydrothermal gold deposits are found within the region, as listed below, with copper-molybdenum mineralisation being rare. In the Archipelago, the gold deposits are principally of epithermal origin, and often have an earlier precursor, weak porphyry Cu stage, while some of the porphyries have later gold and barren breccia pipe over prints. Some, such as at Lepanto and Nena (Frieda River), have high grade, high sulphidation late stage enargite rich copper-gold phases and late stage epithermal veins (Disini, et. al. this volume). Evidence suggests that some of the epithermal veins at Lepanto may be related to an earlier porphyry system at the same location, now removed by erosion and intrusion.

Virtually all of the Archipelago porphyry deposits are of late Tertiary age and occur in island arc settings. Those on the main island of New Guinea (including Irian Jaya), particularly in the Ertzberg Mineral District (eg. Grasberg) and at Ok Tedi, are developed on continental crust of the Australian Block. Many in the Philippines and outer islands however, are over ophiolitic crust.

Exceptions in the Philippines include the Atlas and Sipalay mines. These deposits are developed in fault bounded micro-plates of continental crust within the ophiolite terrane. They represent tectonically displaced, preserved older Cu-Mo mineralisation from the late Mesozoic, and have supergene blankets formed below a Cretaceous weathering surface. They have subsequently been overprinted by fracture controlled Tertiary gold rich mineralisation (A Cuthbertson, Pers. Com.).

The mineralising porphyry intrusions of the region show a strong bias towards quartz diorites, although those developed on continental crust, as in the Ertzberg Mineral District and at Ok Tedi, are associated with quartz-monzonites. Within these island arc settings, advanced argillic quartz-alunite lithocaps are commonly associated with both porphyry and epithermal deposits (Andrew, 1995), presenting a different gross alteration envelope to most of those in the Americas.

Within Australasia and the South-east Asian Archipelago, narrow diameter, depth extensive, high hypogene grade porphyry plugs are another characteristic, that on present discovery patterns, are less well known elsewhere in the world (A Cuthbertson, Pers. Com.).

A number of major relatively low grade deposits are mined and others have been outlined, in south-eastern China (eg. Dexing). These are of Mesozoic age and occur on the margin of the

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Table 1 Major porphyry deposits of the Asia - Pacific.

Deposit	Country	Age	Metals	Size & year
Namosi	Fiji (Viti Levu)	Tertiary	Cu-Au	930 mt @ 0.43% Cu, 0.14 g/t Au 1995
Panguna	Papua New Guinea	Pliocene	Cu-Au	945 mt @ 0.48% Cu, 0.56 g/t Au, 1977
Ok Tedi	Papua New Guinea	Pleistocene	Cu-Au	510 mt @ 0.69%Cu, 0.63 g/t Au, 1993
Frieda River &	Papua New Guinea	Miocene	Cu-Au	1008 mt @ 0.5%Cu, 0.3 g/t Au, 1989
Nena				45 mt @ 2.7% Cu, 0.2-1.3 g/t Au ,1994
Grasberg - O'pit	Indonesia (Irian Jaya)	Pliocene	Cu-Au	1153 mt @ 1.06% Cu, 1.27 g/t Au, 1997
- U'grnd				605 mt @ 1.2% Cu, 1.1 g/t Au, 1997
Batu Hijau	Indonesia (Sumbawa)	Tertiary ?	Cu-Au	1000 mt @ 0.6% Cu, 0.5 g/t Au, 1997
Monywa	Myanma	Miocene	Cu	up to 1000 mt @ 0.41% Cu, 1997
Far South East	Philippines (Luzon)	Pleistocene	Cu-Au	650 mt @ 0.65% Cu, 1.33 g/t Au 1998
Lepanto				36.3 mt @ 2.9% Cu, 3.4 g/t Au Hist. Prod.
Victoria				11 mt @ 7.3 g/t Au, 150-300 t Au potential
Santo Tomas II	Philippines (Luzon)	Miocene	Cu-Au	364 mt @ 0.33% Cu, 0.64 g/t Au, Res+Prod
Dizon,	Philippines (Luzon)	Miocene	Cu-Au	140 mt @ 0.43% Cu, 0.93 g/t Au, Start
Atlas - Lutopan	Philippines (Cebu)	Cretaceous	Cu-Au	540 mt @ 0.5% Cu, 0.25 g/t Au - Prod+Res
Carmen				396 mt @ 0.5% Cu, 0.23 g/t Au, - Prod+Res
Biga				443 mt @ 0.43% Cu, 0.25 g/t Au, - Prod+Res
Tapian	Philippines (Marinduque)	Tertiary	Cu-Au	177 mt 0.52% Cu, 0.12 g/t Au (startup)
Sipalay	Philippines (Negros)	Cretaceous ?	Cu-Au	884 mt @ 0.5% Cu, 0.34 g/t Au (1978)
Mamut	Malaysia (Sabah)	Tertiary	Cu-Au	100 mt @ 0.5% Cu , 0.5 g/ Au (1993)
Dexing Group	China (Jiangxi)	Jur.-Cretac.	Cu-Mo	+1500 mt @ 0.46% Cu, 0.15 g/t Au, 1992
Northparkes	Australia (NSW)	Ordovician	Cu-Au	121 mt @ 1.1% Cu, 0.5 g/t Au, 1995
Cadia Hill	Australia (NSW)	Ordovician	Cu-Au	350 mt @ 0.15% Cu, 0.65 g/t Au, 1997

NOTE: Grades of <0.01% Mo and <0.1 g/t Au are generally not quoted in any of these tables, The abbreviations: g/t = grams per tonne; t = tonnes; mt = million tonnes; Res = reserve or resource; Prod = production.

Asia-Pacific belt, influenced in part also by the eastern termination of the Tethyan Belt. Other Mesozoic deposits are found on Peninsular Malaysia.

On mainland, Australia, two economic Palaeozoic porphyry copper-gold deposits are currently being mined, both associated with a major Ordovician andesitic episode in New South Wales, while in Queensland a series of middle Palaeozoic epithermal gold deposits are mined, mainly of Permo-Carboniferous age. A series of large mesothermal vein gold deposits in south-eastern Australia may be related to mid-Palaeozoic magmatism.

Many significant deposits within the Asia Pacific appear to be localised at the intersection of major faults and cross structures, and are clustered along the dominant structure. This may be either parallel to the trend of a mineral belt, as is the case along the great Philippine Fault, or in groups along cross structures developed at an angle to the overall belt, as in New Guinea.

Table 2 Selected major hydrothermal gold deposits of the Asia - Pacific.

Deposit	Country	Age	Style	Size & year
Lihir	Papua New Guinea	Pleistocene	Lo Sulphidation	480 mt @ 2.8 g/t Au =1350t Au, 1997
Porgera - Main	Papua New Guinea	Miocene	Lo Sulphidation	78 mt @ 3.7 g/t Au = 290t Au, 1996
Zone 7				4.5 mt @ 22 g/t Au =99t Au, 1996
Misima	Papua New Guinea	Miocene	Lo Sulphidation	56mt @ 1.38g/t Au, 21g/t Ag =77t Au, Start
Kelian	Indonesia (Kalimantan)	Miocene	Lo Sulphidation	56 mt @ 2.34 g/t Au =130t Au, 1997
Mt Muro	Indonesia (Kalimantan)	Miocene	Lo Sulphidation	8.5 mt @ 3.92 g/t Au =33t Au, 1994
Toka Tindung	Indonesia (Sulawesi)	Miocene	Lo Sulphidation	11.6 mt @ 2.8 g/t Au = 32t Au, 1997
Mesel	Indonesia (Sulawesi)	Miocene	Sediment Host	7.8 mt @ 7.3 g/t Au =57t Au, 1988
Antamok/Acupan	Philippines (Luzon)	Pliocene	Lo Sulphidation	350 t Au mined to date
Hishikari	Japan (Kyushu)	Pleistocene	Lo Sulphidation	3.2 mt @ 63 g/t Au plus
				2 mt @ 25 g/t Au =250t Au, Start
Kubaka	Russia (Kamchatka Penin.)	Tertiary	Epithermal	3.5 mt @ 17.8 g/t Au =62t Au, 1998
Kidston	Australia (Queensland)	Perm-Carb.	Breccia pipe	94 mt @ 1.48 g/t Au =140t Au, Start
Mt Leyshon	Australia (Queensland)	Perm-Carb.	Breccia pipe	48 mt @ 1.27 g/t Au =60t Au, 1995
Pajingo &	Australia (Queensland)	Carbonif.	Lo Sulphidation	15 mt @ 10 g/t Au, 38 g/t Ag Mined
Vera-Nancy				1.75 mt @ 13.6 g/t Au =173t Au, 1997
Emperor	Fiji (Viti Levu)	Pliocene	Lo Sulphidation	27 mt 10 g/t Au =270t Au, - Prod+Res

The Americas

As a reflection of the history of the development of porphyry copper deposits, more experience has been accumulated from the Americas than from elsewhere in the world. This knowledge may be extrapolated with caution to other parts of the world, while appreciating that it will not be universally applicable.

The main concentrations of porphyry related and other hydrothermal copper and gold deposits in the Americas lie within the early Mesozoic to late Cainozoic Cordilleran Orogen on the western margin of both continents. The resultant mountain ranges extend for over 15 000 km, from Alaska, to the tip of Cape Horne, and are from 250 to 1000 km wide. Tectono-magmatic activity within this belt was episodic and progressive, with the late Cretaceous to Tertiary Laramide event being one such pulse. Porphyry related and other hydrothermal mineralisation is spread over much of the length of the Cordilleran Orogen, although there are pronounced intervals to which large economic deposits are restricted. These generally define restricted elongate clusters within the orogen, as indicated on Fig. 1.

There is also a partitioning of intervals into which significant deposits of different metal associations fall. For example, there are provinces in which hydrothermal gold deposits predominate with lesser porphyry coppers as in Alaska, Nevada and in the Maricunga Belt in Chile; the hypogene Cu deposits of British Columbia; the great cluster of Cu-Mo porphyry deposits of Arizona; or the younger Cu-Au rich porphyries of western Argentina.

In addition, there are intervals in which particular ages of mineralisation predominate. Examples are the large component of early Jurassic to Cretaceous deposits in Western Canada; and the predominantly late Cretaceous to mid Tertiary deposits of the "South-west" US and northern Mexico. Despite this, within individual clusters there is often an overlap and/or gradual zonation of deposits of different ages, as in the interspersed younger

Table 3 Selected major porphyry deposits in the Cordillera of the America's.

Deposit	Country	Age	Metals	Size & year
Fort Knox	USA (Alaska)	Upper Cretac.	Au	158 mt @ 0.83 g/t Au, Start-up
Granisle	Canada (BC)	Eocene	Cu-Au	52 mt @ 0.41% Cu, 0.21 g/t Au, Mined
Brenda	Canada (BC)	Upper Jurassic	Cu-Mo	186 mt @ 0.17%Cu, 0.045% Mo, Mined
Gibraltar	Canada (BC)	Lower Jurassic	Cu-Mo	326 mt @ 0.37% Cu, 0.016% Mo, Start-up
Highland Valley	Canada (BC)	Lower Jurassic	Cu	2000 mt @ 0.45%Cu, 0.3 g/t Au, Prod+Res
Afton-Ajax	Canada (BC)	Lower Jurassic	Cu-Au	66 mt @ 0.77% Cu, 0.55 g/t Au, Prod+Res
Ingerbelle	Canada (BC)	Lower Jurassic	Cu-Au	260 mt @ 0.42% Cu, 0.22 g/t Au, Prod+Res
Island Copper	Canada (BC)	Upper Jurassic	Cu-Mo-Au	257 mt @ 0.45% Cu, 0.01% Mo, 0.1 g/t Au, Mined
Butte	USA (Montana)	Upr Cretaceous to Lwr Tertiary	Cu	U'ground - 450 mt @ 2% Cu, 0.23 g/t Au, Mined O'pit - 1000 mt @ 0.6% Cu - Estimate
Bingham Canyon	USA (Utah)	Upper Eocene	Cu-Au	1550 mt @ 0.77%Cu 0.05%Mo 0.52g/t Au Prod., 1998 >1100 mt @ 0.59%Cu 0.03%Mo 0.38g/t Au Res., 1998
Ely (Robinson)	USA (Nevada)	Jur.-Lwr Cret.	Cu-Au	255 mt @ 1.1% Cu, Prod + 82 mt @ 0.67% Cu, Res
Ajo	USA (Arizona)	Palaeocene	Cu-Au	580 mt @ 0.7% Cu, 0.3 g/t Au, Prod+Res, 1984
Bagdad - mill - leach	USA (Arizona)	U Cretaceous	Cu-Mo	308 mt @ 0.53% Cu, 0.012 % Mo, Prod. 1288 mt @ 0.37% Cu, 0.012 % Mo, Prod+Res.
Bisbee	USA (Arizona)	Middle Jurassic	Cu-Au	152 mt @ 2.3% Cu, 21 g/t Ag, 0.6 g/t Au, Prod. 120 mt @ 0.8% Cu, Prod + 210 mt @ 0.4% Cu, Res.
Morenci - mill - leach	USA (Arizona)	Eocene to Palaeocene	Cu-Au	1830 mt @ 0.8% Cu Prod.+Res., 1991 1110 mt @ 0.33% Cu, Res., 1991
Mission	USA (Arizona)	Palaeocene	Cu	1175 @ 0.67% Cu - Prod.+Res., 1994
Sierrita	USA (Arizona)	Palaeocene	Cu-Mo	1000 mt @ 0.28% Cu, 0.03% Mo, Res., 1998
San Manuel	USA (Arizona)	Palaeocene	Cu	1280 mt @ 0.67% Cu, Prod + Res., 1994
Inspiration	USA (Arizona)	Palaeocene	Cu	290mt @ 1.3%Cu + 480mt @ 0.57%Cu Prod+Res 1991
Pinto Valley	USA (Arizona)	Palaeocene	Cu	258mt @ 0.44%Cu Prod + 641mt @ 0.38%Cu Res 1994
Ray	USA (Arizona)	Palaeocene	Cu	582mt @ 0.7%Cu Prod + 1140mt @ 0.6%Cu Res 1994
Twin Buttes	USA (Arizona)	Palaeocene	Cu	780 mt @ 0.73% Cu, Start-up
Chino/Santa Rita	USA (New Mex)	Palaeocene	Cu	705 mt @ 0.85% Cu, Prod.+Res., 1991
Cananea	Mexico (Sonora)	Palaeocene	Cu	1850 mt @ 0.7% Cu, 1987
La Caridad	Mexico (Sonora)	Lower Eocene	Cu	700 mt @ 0.7%Cu 1976; 1500 mt @ 0.4%Cu 1995
Cerro Colorado	Panama	Late Miocene	Cu-Mo	1300 mt @ 0.76% Cu, 0.01% Mo, 1995
Petaquilla	Panama	Lower Oligocene	Cu-Au	1200 mt @ 0.6% Cu, + up to 0.56 g/t Au, 1995
Cuajone	Peru	Eocene	Cu	480 mt @ 1% Cu, Startup
Toquepala	Peru	Eoc-Palaeocene	Cu	44 mt @ 1.09% Cu, Startup
Collahuasi	Chile	Oligocene	Cu	3100 mt @ 0.82% Cu, 1997
El Abra	Chile	Oligocene	Cu	797 mt @ 0.53% Cu, 1998
Radomiro Tomic	Chile	Oligocene	Cu	>1000 mt @ 0.56% Cu, 1998
Chuquicamata	Chile	Oligocene	Cu	9928 mt @ 0.52% Cu, 1990 (after 75 yrs mining)
La Escondida	Chile	Oligocene	Cu-Mo	2140 mt @ 1.24% Cu (0.7% cutoff), 1998
El Salvador	Chile	Eocene	Cu	300 mt @ 2.4% Cu Prod, 400 mt @ 0.9% Cu Res
Lobo-Marte	Chile	Miocene	Au	126 mt @ 1.5 g/t Au, 1991
Candelaria	Chile	Cretaceous	Cu-Au	400 mt @ 1% Cu, 0.25 g/t Au, Res., 1998
El Teniente	Chile	Pliocene	Cu	2850 mt @ 1.3% Cu, Prod.+Res., 1990
Los Bronces	Chile	Mio-Pliocene	Cu-Mo	1320 mt @ 0.81% Cu, 0.035% Mo, 1990
Andina	Chile	Mio-Pliocene	Cu-Mo	422 mt @ 1.09% Cu, 1990
Agua Rica	Argentina	Miocene	Cu-Au	750 mt @ 0.62% Cu, 0.037% Mo, 0.23 g/t Au, 1998
Alumbrera	Argentina	Miocene	Cu-Au	780 mt @ 0.52% Cu, 0.67 g/t Au, 1997

NOTE: There are over 75 significant porphyry deposits in the North American sector of the Cordillera alone.

porphyries of British Columbia and the gradation from early to late Tertiary from north to south and west to east in Peru and Chile.

The Cordilleran Orogen itself is not uniform. It has been superimposed on a variety of earlier geological and tectonic settings and is manifested in different forms.

The west coast of Canada and Alaska for instance is composed of a series of long narrow accretionary magmatic terranes which were progressively juxtaposed during the Mesozoic mineralising epoch, accompanied by batholith emplacement and extensive co-magmatic andesitic volcanics. This setting is similar in some respects to that seen in the island arcs of the Asia-Pacific, but at a different stage of maturity.

Further south in the great porphyry districts of the "South-west" US, the main Cordilleran Orogen deforms thicker continental crust and mineralised porphyry stocks intrude basement of Precambrian and Palaeozoic metamorphics overlain by passive margin shelf sediments. In southern Central America the country rock is primitive island arc volcanics on oceanic crust, as in the porphyry district of Panama. In South America the main belt of deposits occurs within a zone of continental crust and pre-mineralisation accreted continental crust terranes.

Major hydrothermal gold deposits are found in a wide variety of country rocks within the Cordillera of both North and South America (see Table 4). Some are porphyry gold deposits (see Table 3), others are directly related to porphyry systems, while others, although apparently of hydrothermal origin and associated with magmatic activity within the orogen, are not obviously, or strictly "porphyry related".

Like the hydrothermal gold deposits, there is also a wide variety of economic "porphyry related" Cu-Mo and Cu-Au deposits. These range from classic stocks and plugs, or dykes or dyke swarms, with disseminated and stockwork mineralisation; segregations within the

Table 4 Selected major hydrothermal gold deposits in the Cordillera of the Americas.

Deposit	Country	Age	Style	Size & year
Montana Tunnels	USA (Montana)	Mid Eocene	Diatreme breccia	61mt @ 0.96 g/t Au, 12 g/t Ag, =60t Au, Start-up
Golden Sunlight	USA (Montana)	Oligocene	Breccia	42.5 mt @ 1.85 g/t Au, =80t Au, 1988
Mercur	USA (Utah)	Oligocene	Sediment Hosted	39 t Au - 6.5 g/t ore & 45 t Au - 2.3 g/t ore
Sleeper	USA (Nevada)	Miocene	Lo Sulphidation	50mt @ 1.6 g/t Au + >30 g/t bonanza, Prod+Res
Jerritt Canyon	USA (Nevada)	Eocene ?	Sediment Hosted	33 mt @ 6.5 g/t Au, =215t Au, Start-up
Twin Creeks	USA (Nevada)	Eocene	Sediment Hosted	124 mt @ 2.1 g/t Au, =260t Au, 1990?
Goldstrike	USA (Nevada)	U Cret-Mid Tert	Sediment Hosted	137 mt @ 4.25 g/t Au + Prod. =1330 t Au, 1995
Carlin	USA (Nevada)	Oligocene ?	Sediment Hosted	12.5 mt @ 9.26 g/t Au + lo grade =135t Au, 1991
Gold Quarry	USA (Nevada)	Oligocene ?	Sediment Hosted	300 mt @ 1.5 g/t Au = 450t Au, 1995
Battle Mountain	USA (Nevada)	Eocene	Porphyry/skarn	180 t Au, @ grades 1 to 7 g/t Au + Cu, 1994
Pipeline	USA (Nevada)	Jurassic ?	Sediment Hosted	46mt @ 3.2g/t + 69mt @ 1.6g/t =260t Au, 1995
Round Mountain	USA (Nevada)	Oligocene	Low sulphidation	200 mt @ 1.5 g/t Au =300t Au, 1994
Comstock	USA (Nevada)	Miocene	High sulphidation	260t Au + 6000t Ag from bonanza lodes
Cripple Creek	USA (Colorado)	Oligocene	High sulphidation	Historic production of 750 t Au
Mesquite	USA (California)	Oligocene	Low sulphidation	86 mt @ 1.71 g/t Au = 150t Au, 1989
McLaughlin	USA (California)	Pleistocene	Low sulphidation	17.5 mt @ 5.2 g/t Au = 91t Au, Start-up, 1984
Pueblo Viejo	Dominican Repub.	Cretaceous	High sulphidation	50mt @ 4 g/t Au, Prod.,+ 100mt @ 3 g/t Au, Res.
Yanacocha	Peru	Miocene	High sulphidation	92mt @ 0.9-1.6g/t Au = 118t Au, Start-up
Pierina	Peru	Miocene ?	High sulphidation	225 t Au, 1735t Ag, 1998
Kori Kollo	Bolivia	Miocene	Low sulphidation porphyry	10mt @ 1.6 g/t Au, 25g/t Ag, oxide; + 64mt @ 2.26g/t Au, 14g/t Ag, sulphide =160t Au, Start
La Coipa	Chile	Mioc-Oligocene	High sulphidation	52mt @ 1.6g/t Au, 60g/t Ag, + 9mt @ 0.2g/t Au, 170g/t Ag, =95t Au, Start
Refugio	Chile	Miocene	Porphyry	216 mt @ 0.88 g/t Au, 1997
El Indio & Tambo	Chile	Miocene	High sulphidation	23mt @ 6.6g/t Au, 4% Cu, + 0.19mt @ 209g/t Au & 23mt @ 4.4g/t Au =295 t Au, Start

apices of zoned batholiths; skarns; breccia pipes; supergene caps over low grade hypogene mineralisation, etc.. The associated porphyries also have a range of compositions, from quartz-diorite to porphyritic granite, and alteration patterns vary. There is not a single simple model.

In addition there are other hydrothermal deposits such as the Mesozoic "manto" deposits and the Candelaria (skarn?) orebody in coastal Chile which are pre-porphyry episode, with no recognised associated porphyry body, although they are found in the interval along the Cordillera where superior porphyry deposits are localised.

Other commodities are also found in closely analogous porphyry style deposits within the Cordillera, particularly the Mo-(W) deposits of Colorado such as Climax and Henderson, the skarn scheelite orebodies of Tem Piute in Nevada, or the Sn-Ag porphyries of Bolivia.

The location of significant hydrothermal deposits, although localised by cross structures, appears to be strongly influenced in places by major structures such as the trend parallel West Fissure zone in northern Chile, or the old cross structures in the "South-west" US. Almost all of the major porphyry deposits were emplaced during the compressive phase of orogenesis and subduction, while some of the porphyry Mo-W and Au deposits were emplaced during extensional phases.

Some Palaeozoic porphyry style mineralisation is known in the Appalachians to the east, as at the Devonian Gaspé skarn mine in Quebec, while weak Archaean porphyry style mineralisation is known on the shield.

Tethyan Belt

The Tethyan orogenic belt is on a comparable scale to, and broadly coeval with, the Cordilleran orogenic belt of the Americas. It is largely defined by the southern margin of the Eurasian Plate, and occurs predominantly to the north of the suture defining its collision zone with the African, Arabian and Indo-Australian Plates to the south (Fig. 1). As such the Sunda-Banda arc in Myanma and Indonesia (see the Asia-Pacific section) is a branch of the Tethyan Belt.

The main Tethyan orogenic belt extends from southern China and Indochina, through the Himalayas of Tibet and northern India to the Pamirs, before being off-set by around 1500 km along a major NE-SW trending sinistral transform in western Pakistan and Afghanistan to continue into southern Iran. It passes up the backbone of Iran, through the Caucasus mountains in Azerbaijan, Georgia and Armenia, through Turkey and then northern Greece, Bulgaria, Macedonia, Serbia, Romania and Hungary to the Alps of central Europe, south through Italy, to north Africa and southern Iberia.

Like the Cordilleran Orogen of the Americas and the South-east Asian Archipelago, tectonism commenced in the early Mesozoic and continues to the present, with a major burst in the late Cretaceous and Tertiary. Unlike the orogens in the Asia-Pacific and the Americas described above, the Tethyan Belt is largely bordered by continental crust, being the result of subduction of the Tethys sea floor and the compaction of the sediments deposited on the leading edges of Eurasia and Gondwana. Prior to the collision of the continental crustal blocks however, there was a period of subduction analogous to the Andean belt. Before that again, a series of sliver-like displaced terranes progressively collided and accreted to Eurasia during the late Palaeozoic and Mesozoic to produce an east-west tectonic framework to the north of the Tethyan, particularly in Central Asia and China. In addition a series of plateaus lie within the Tethyan Orogenic belt representing "mega-boudins" of less deformed crust, possibly analogous to the Colorado Plateau in North America.

Within the broader orogenic belt, which extends for around 10 000 km and may be 500 to 1200 km wide, there are a series of often linear clusters of deposits within narrower arc segments which are a few tens to more than a hundred kilometres wide. These contain porphyry copper type deposits, as well as epithermal vein systems and high sulphidation massive sulphide enargite rich orebodies.

The Tethyan Belt, despite crossing some of the most long populated areas of the world, is at a far less mature stage of exploration than the Americas in particular, where never the less, deposits such as Escondida were only discovered in recent times. Although a substantial number of mineral occurrence are known within the belt, only a few have so far been shown to have both high tonnage and high grade (Gilmour, et. al., 1995). However, high grade supergene mineralisation is known, as at Sar Cheshmeh in Iran (Samani, et. al. this volume), while high grade skarn ore has been delineated also, as at Yulong in China/Tibet (Sillitoe, this volume). Other high grade deposits are mined in the Balkans, as at Bor-Majdanpek (Herrington, et. al., this volume) and at Chelopech in Bulgaria.

While Table 5 below is less impressive than the equivalent listing for the Americas and the Asia-Pacific, it is not inconceivable that, as in those other belts, there are specific localised areas where the conditions prevail to produce further superior deposits (of the type described by Sillitoe, this volume) such as Escondida and Grasberg.

Table 5 Selected porphyry copper and gold deposits of the Tethyan Belt in Asia & Europe.

Deposit	Country	Age	Style	Size & year
Recsk	Hungary	Upper Eocene	Porphyry + skarn	105 mt @ 0.97% Cu + 67 mt @ 1.6% Cu, 1995
Moldova Noua	Romania	Late Cretaceous	Porphyry	500 mt @ 0.35% Cu, 1998 (un-mined resource)
Rosia Poieni	Romania	Neogene	Porphyry	+1000 mt @ 0.4% Cu (un-mined resource)
Bor	Serbia	Upr Cretaceous	Porphyry and Hi sulphidation	450 mt @ 0.6% Cu, and 100 mt @ 1% Cu+Au, Prod+Res, 1998
Majdanpek	Serbia	Upr Cretaceous	Porphyry	1000 mt @ 0.6% Cu, 0.3 g/t Au, Prod+Res, 1998
Veliki Krivelj	Serbia	Upr Cretaceous	Porphyry	750 mt @ 0,44% Cu ?
Assarel	Bulgaria	Upr Cretaceous	Porphyry	360 mt @ 0.44% Cu ?
Medet	Bulgaria	Upr Cretaceous	Porphyry	200 mt @ 0.34% Cu ?
Elatsite	Bulgaria	Upr Cretaceous	Porphyry	260 mt @ 0.37% Cu ?
Chelopech	Bulgaria	Cretaceous	Hi sulphidation	>32 mt @ 5.3 g/t Au, 1.38% Cu, 1994
Skouries	Greece	Cretaceous	Porphyry	500 mt @ 0.47 g/t Au, 0.37% Cu, 1998
Kajaran	Armenia	?	Porphyry	Annual Prod. 8 mt @ 0.2% Cu, 0.05% Mo in 1990
Sar Cheshmeh	Iran	Miocene	Porphyry	1200mt @ 1.2%Cu, 0.03%Mo, 0.27 g/t Au, 1990
Meyduk	Iran	Miocene ?	Porphyry	125 mt @ 1.15% Cu, 1994
Chagai Hills	Pakistan	?	Porphyry	Large tonnage @ 0.37% Cu, 0.4 g/t Au, 1998
Saindak	Pakistan		Porphyry	100 mt @ 0.43% Cu, 0.4g/t Au, 1978
Skalnoye	Tajikistan	Tertiary	Epithermal	contained 100t Au, 1995
Yulong	China (Tibet)	Lower Tertiary	Porphyry/skarn	850 mt @ 0.84% Cu, Res., 1994

Note: In addition to those tabulated above there are a number of medium sized hydrothermal gold deposits along the belt in Laos, China, Tajikistan, Armenia, Georgia Turkey, Greece, Eastern Europe, etc..

Central Asia

In the context of this conference, Central Asia encompasses the republics of Uzbekistan, Kirgizstan, Tadjikistan, Kazakhstan and southern Russia (Sokolov, this volume). Other belts within the Asian mainland will be briefly mentioned in the following section.

Porphyry Cu-Au, Cu-Mo, Mo, Mo-W and W deposits and major Au provinces are found in a series of clusters and belts in Central Asia and southern Siberia, with different ages including Cambrian, Silurian, Devono-Carboniferous to Permo-Carboniferous. Of all of these however, the most significant is a U-shaped cluster of major porphyry Cu-Au-Mo porphyry deposits on the eastern and southern margins of the Kazakhstan-North Tien Shan Massif in Kazakhstan and Uzbekistan, and immediately outboard of this to the south, the great South Tien Shan belt of hydrothermal gold deposits. Both encompass mineralisation of Permo-Carboniferous age. The porphyry belt extends over a length of around 1000 km, while the South Tien Shan, which is probably the greatest gold accumulation in the world after the Witwatersrand, is over 1500 km long.

The Kazakhstan-North Tien Shan Massif is bounded immediately to the west by the Devono-Carboniferous Uralian Fold Belt which separates it from the East European-Baltic craton, and to the south the South Tien Shan mobile belt separates it from the long sliver of accreted terrane, the Karakum-Tarim Massif which extends from the Caspian sea to eastern China. To the east is the complex, broad Central Asiatic Orogenic Belt which is in turn bounded to the north-east by the Siberian Craton (Zonenshain, et. al., 1990). The composite Karakum-Tarim Massif was one of the linear slivers, now disposed east-west, that progressively collided and were accreted onto the Eurasian Plate in the late Palaeozoic, ahead of the main Tethyan event.

The Permo-Carboniferous porphyry belt is in part on the Kazakhstan-North Tien Shan Massif to the south, but straddles the boundary into the Central Asiatic Orogenic Belt to the east (see the Permo-Carboniferous deposits listed in Table 6). The South Tien Shan gold deposits are entirely within the narrow South Tien Shan mobile belt and include deposits such as Muruntau, Kumtor, Daugiztau, Amantaitau, Zarmitan, Upper Kumar, etc., as listed in Table 6.

A number of low grade porphyry Cu deposits are known within the Devono-Carboniferous Uralian Belt, while a linear NW-SE trend of porphyry copper deposits, such as Boschekul and gold deposits such as Vasilkovskoye is found to the north-east of the Kazakhstan-North Tien Shan Massif. Further to the north-east again a cluster of low grade Silurian Mo and Mo-Cu porphyries are within the Central Asiatic Orogenic Belt, closer to the Siberian Craton.

Table 6 Selected porphyry copper and hydrothermal gold deposits of Central Asia.

Deposit	Country	Age	Style	Size & year
Muruntau	Uzbekistan	Permo-Carb	Hydrothermal - Sediment Hosted	Approx 1500 mt @ 3 g/t Au, =4500t Au, 1995
Kumtor	Kyrgyzstan	Permo-Carb	Hydrothermal	200mt @ 3.6 g/t Au, =715t Au, Orig. Res. 1994
Daugiztau	Uzbekistan	Permo-Carb	Hydrothermal	135 mt @ 4 g/t Au =540t Au, 1995
Amantaitau	Uzbekistan	Permo-Carb	Hydrothermal	60 mt @ 3 g/t Au =180t Au, Res., 1998
Zarmitan	Uzbekistan	Permo-Carb	Hydrothermal	80 mt @ 3 g/t Au =250t Au, 1998
Upper Kumar	Uzbekistan	Permo-Carb	Hydrothermal	50 mt @ 6 g/t Au =300t Au, 1998
Kokpatass	Uzbekistan	Permo-Carb	Hydrothermal	175 mt @ 3.5 g/t Au, =620t Au, Res., 1995
Myutenbai	Uzbekistan	Permo-Carb	Hydrothermal	325 mt @ 1.9 g/t Au =620t Au, 1998
Kal'makyr	Uzbekistan	Permo-Carb	Porphyry	1500mt @ 0.4% Cu, 0.3 g/t Au, 0.05% Mo, Prod+Res
Dalneye	Uzbekistan	Permo-Carb	Porphyry	2500mt @ 0.4% Cu, 0.35 g/t Au, Prod+Res, 1995
Kounrad	Kazakhstan	Permo-Carb	Porphyry	+200 mt @ 0.7% Cu, 0.05% Mo +Au, Prod+Res
Aktogay	Kazakhstan	Permo-Carb	Porphyry	1500 mt @ 0.39% total resource, 1992
Sayak	Kazakhstan	Permo-Carb	Skarn	Annual Prod. 2.6mt @ 0.73% Cu, 0.05% Mo, 1990
Sorsk	Russia (Siberia)	Silurian	Porphyry	Annual Prod. 9.35 mt @ 0.06% Cu, 0.05% Mo, 1992
Boschekul	Kazakhstan	Cambrian	Porphyry	1000 mt @ 0.67% Cu, Res., 1992
Vasilkovskoye	Kazakhstan	Cambrian ?	Epithermal	138 mt @ 3 g/t Au =420t Au, 1995

Note: There is probably at least 8000t of recoverable gold known in the Permo-Carboniferous deposits of the South Tien Shan belt.

Other Porphyry/Hydrothermal Provinces

Porphyry style mineralisation and hydrothermal gold are known in a variety of other locations and orogenic belts throughout the world, although only a limited number contain economic resources as known at present. Table 7 lists some of the more significant. Some of these have been previously mentioned, including the belt of generally sub-economic copper and Mo-W deposits in the Palaeozoic Appalachian Orogen in eastern North America, including Gaspé in Quebec; and the Palaeozoic Cu-Au and Au deposits of eastern Australia.

There are a number of poorly defined Palaeozoic belts within Siberia, Mongolia and northern China, and potentially in central China related to the accretion of displaced terranes ahead of the Tethyan Belt. These are oriented east-west along the sutures between the accreted terranes. The most significant group forms a loosely defined belt of clusters across southern Russia, Mongolia and north-eastern China (shown on Fig. 1), including the large Erdenet Oovo porphyry Cu-Mo mine in Mongolia and the old Baley-Taseyev high sulphidation gold mine in Siberia. These occurrences are found on the southern rim of the Siberian Craton and the adjacent east-west trending Permian to Cretaceous Mongol-Okhotsk Fold Belt. Mineralisation apparently varies from Permian to Cretaceous in age. Individual clusters may be oblique to the main trend, such as the major NW-SE trending cluster in Mongolia which includes Erdenet and the discoveries in the South Gobi.

Another occurrence of possible economic significance is the Proterozoic Haib deposit in southern Namibia, while the large Proterozoic quartz vein network at Malanjkand in India could have porphyry affinities. Some have also argued that the early Middle Proterozoic Aitik Cu-Au deposit in northern Sweden has porphyry affinities. Porphyry style copper occurrences of no economic significance are recorded from the Archaean of Canada and Australia. There are other great hydrothermal breccia "pipe" hosted deposits within the

Table 7 Selected other important porphyry and hydrothermal copper and/or gold deposits.

Deposit	Country	Age	Style	Size & year
Appalachian Belt				
Gaspé	Canada (Quebec)	Devonian	Porphyry-skarn	48mt @ 1.5%Cu, u'g + 300mt @ 0.4%Cu, o'pit, 1977
Uralian Orogen				
Jubeleinoe	Kazakhstan	Permo-Carbonif.	Epithermal	24 mt @ 3.4 g/t Au =80t Au, 1995
Southern Russia, Mongolia & North-east China				
Erdenetin Oovo	Mongolia	Triassic-Jurassic	Porphyry	1600 mt @ 0.57% Cu, 0.016% Mo, 1998
Boroo	Mongolia	?	Epithermal	15 mt @ 2.5 g/t Au, Res., 1995
Duobaoshan	China (Heilongjiang)	Permian	Porphyry	500 mt @ 0.47% Cu, 0.14 g/t Au, Prod+Res, 1995
Siberia				
Sukhoi Log	Russia (Siberia)	Proterozoic	Hydrothermal sediment hosted	1200 to 1800t Au @ 2.5 g/t Au, 1995
Central China				
Saishitang Dist.	China (Qinghai)	Triassic	Porphyry	50 mt @ 1.13% Cu, 0.48 g/t Au, Res., 1995
Southern Africa				
Haib	Namibia	Proterozoic	Porphyry	300 mt @ 0.35% Cu + Mo, 1985
India				
Malanjkand	India (M. Prad)	Lwr Proterozoic	Porphyry ?	790 mt @ 0.83% Cu, 0.2 g/t Au, Res., 1988
Australia				
Olympic Dam	Australia (SA)	Mid Proterozoic	Hydrothermal breccia pipe	Prov. 82 mt @ 2.4% Cu, 0.6 g/t Au, 0.7 kg/t U_3O_8 Prob. 484 mt @ 2.0% Cu, 0.7 g/t Au, 0.6 kg/t U_3O_8 Inf. 1620 mt @ 1.1% Cu, 0.4 g/t Au, 0.4 kg/t U_3O_8
Ernest Henry	Australia (Qld)	Mid Proterozoic	Hydrothermal breccia pipe	166 mt @ 1.1% Cu, 0.54 g/t Au, 1997

Proterozoic, such as Olympic Dam and Ernest Henry within Australia, which are not of a porphyry affinity, but have a strong copper-iron oxide association. Do the processes involved in their formation overlap with those of the porphyry systems ?

Conclusions

This and the following papers demonstrate how the consideration of knowledge and experience from across the world expands our appreciation and understanding of ore occurrence.

As our knowledge has grown, it has become apparent that the porphyry copper/molybdenum/gold deposits in particular, are not the narrow time, geographic and model based ore type they were once considered. They are found through much of the geological time scale and across the world. They occur within a relatively wide range of host rocks, both regionally and at a mine scale. In addition they are associated with a variety of intrusives, both in composition and physical form, and display a wide variation in geometry, metal content, alteration patterns and mineralisation styles. Futher more, they are inter-related on a number of levels with the other hydrothermal ore deposits found within the same orogenic belts.

This diverse set of related ore deposits should not be thought of in terms of a single, or even a series of distinct models. They are the result of members of a family of processes, interacting with a variety of rocks of differing chemical composition and physical properties. This interaction is in turn heavily influenced by structural and tectonic setting, from the continental to the prospect scale. Not all of the potential processes will be represented in any one deposit. With a knowledge of both the range of potential processes, and the geology and structure of a mineralised district we can better predict what styles of mineralisation might occur.

While we have learned a lot about the occurrence of hydrothermal mineralisation, and porphyry deposits in particular, during this century, there is still much to be gained. It is hoped that the papers delivered at this conference, coming as they do from the corners of the Earth, will contribute to the expansion of our knowledge and appreciation.

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