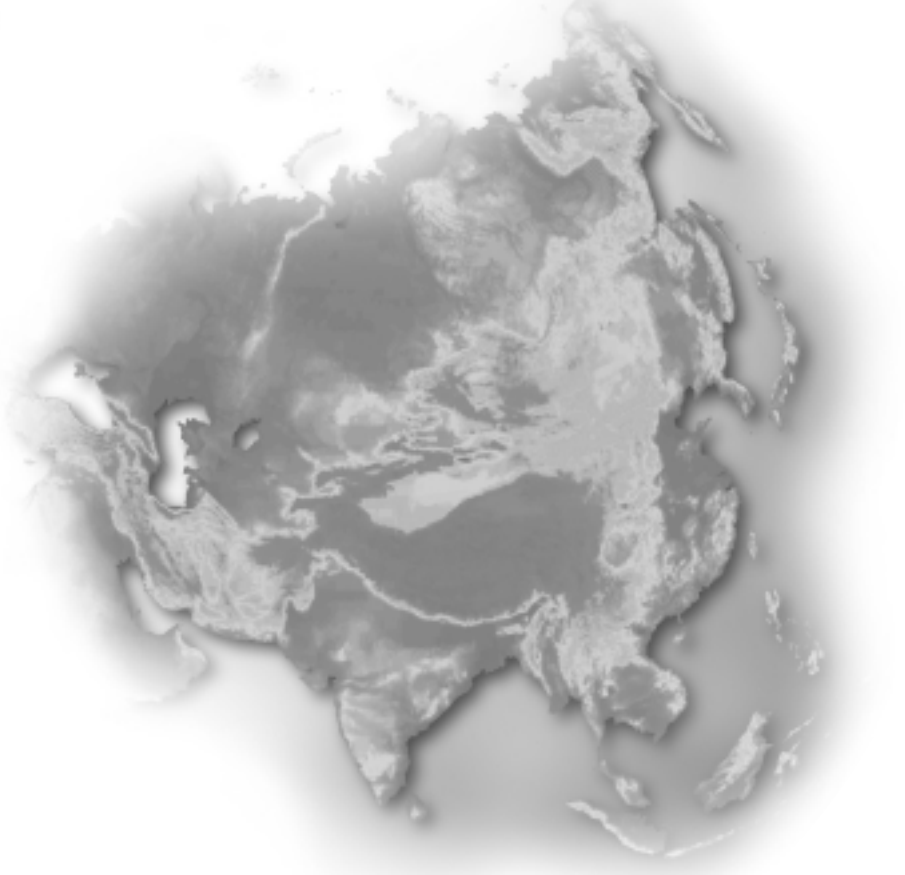
Metal Mining Agency of Japan

Mineral Potential of ASIA



A Forum on Asian metallogeny and ore deposits, exploration and development potential, regulatory and investment climate, and management practicalities

MMAJ

Mineral Potential of ASIA

Metal Mining Agency of Japan
Mineral Resources Information Center

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MMAJ Forum:
Mineral Potential of Asia

The Mineral Resources Information Center of the Metal Mining Agency of Japan (MMAJ) sponsored a Forum on the Mineral Potential of Asia in order to provide information on the mineral resources of Asia to interested parties, to facilitate new private investment in the region. The Forum was held on 21 January, 2002, at the Four Seasons Hotel, Vancouver, Canada, immediately prior to and in conjunction with the Cordilleran Exploration Roundup Convention.

The speakers were all Asian specialists who reviewed the metallogeny, mineral deposits, and potential for exploration and development in the region. The final four speakers also discussed the regulatory and investment climate, plus the practicalities of working in Asia.

This publication includes the abstracts of the presentations, plus a listing of useful references on the mineral resources of Asia. A CD-ROM inside the back cover includes each of the presentations. For further information, please contact the MMAJ Mineral Resources Information Center, or the individual authors.

Metal Mining Agency of Japan

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MMAJ Forum:
Mineral Potential of Asia

Monday, 21 January, 2002
Four Seasons Hotel, Vancouver, Canada

Program: Schedule, topics and speakers

Forum coordinator: **Jeffrey W. Hedenquist**, Ottawa

A.M. Co-chairs: **Koh Naito**, International Affairs, Geological Survey of Japan, AIST
Wayne Spilsbury, General Manager Exploration, Asia-Pacific, Teck Cominco

- Welcome and Purpose of Forum: **Naotoshi Sugiuchi**, Executive Director of MMAJ
- Introduction to the metallogeny and ore deposits of Asia — **Noel White**, consultant, Brisbane
- Siberia and Mongolia — **Alexander Yakubchuk**, consultant, c/o British Natural History Museum
- Far East Russia — **Lance Miller**, Juneau Economic Development Council
- Central Asia — **Reimar Seltmann**, British Natural History Museum
- India — **David Isles**, Grenfell Resources, Perth
- Tethys of Iran and Turkey — **Peter Leaman**, BHP Billiton, Brisbane
- **Toshiro Ozawa**, Consul General of Japan
- Investment trends in Asia — **Bakes Mitchell**, Metals Economics Group, Halifax

P.M. Co-chairs: **Shunso Ishihara**, Senior Advisor, Geological Survey of Japan, AIST
Hugo Dummett, Executive VP Exploration, African Minerals, and Executive VP Project Development, Ivanhoe Mines

- China — **Kaihui Yang**, University of Toronto
- Indochina and Yunnan — **Douglas Kirwin**, Ivanhoe Mines, Vancouver
- Indonesia and the Philippines — **Steve Garwin**, Newmont Mining, Nevada
- Regulatory aspects related to exploration in Asia — **Koh Naito**, AIST, Tsukuba
- Exploration, investment and management strategy in Asia — **David Tyrwhitt**, consultant, Melbourne
- Practicalities of working in Asia: A management perspective — **Nigel Clark**, consultant, Beijing
- Closing remarks — **Atsushi Osame**, Mineral Resources Information Center, MMAJ

Preface:
Purpose of the MMAJ Forum on Mineral Potential of Asia

Asia covers one third of the explorable land surface of the earth, and hosts nearly three fifths of the world population. Despite its size and proven mineral potential, Asia is short of the raw materials that are necessary to sustain the rapid economic growth of its more wealthy regions, and to fuel the development of its emerging nations. An increase in the mineral production of Asia will also provide the boost to local infrastructure that comes with all large-scale development of natural resources.

The Metal Mining Agency of Japan is an arm of the government involved with mineral supplies. Japan is dependent on the world-wide supply of mineral resources, and thus wishes to help ensure a stable and adequate supply of commodities into the global market. As a means of achieving this goal, the agency works with Asian countries to help develop their mining industries. MMAJ also compiles geological and mineral resources information world-wide for potential investors.

As outlined in the Forum, there are world-class ore deposits of all major commodities across Asia, many of them under-developed at present. In addition, there are also vast untapped mineral resources, and many regions are under-explored. Because of the geological potential coupled with local demand, MMAJ believes that Asia has a bright future for continued mineral discovery and development. I hope that this Forum provides you with a useful overview of the Asian minerals sector, and that you will consider becoming involved with the mining potential of these countries.

Mr. Naotoshi Sugiuchi
Executive Director
Metal Mining Agency of Japan

Asia is short of the raw materials that are necessary to sustain the rapid economic growth of its more wealthy regions, and to fuel the development of its emerging nations.

There are world-class ore deposits of all major commodities across Asia, many of them under-developed.

MMAJ wishes to help ensure a stable and adequate supply of commodities into the global market.

Introduction
to the Metallogeny and Ore Deposits of Asia

Noel C. White, consultant, Brisbane, Australia <White.Noel@BigPond.com>

Asia has one third of the Earth's explorable area, and half its population, very unevenly distributed. It has some of the fastest-growing countries, and some of the poorest. It has a major appetite for minerals and metals, both to sustain the growth in developed and developing regions, and to improve the living standards of the underdeveloped ones. Some parts of Asia export mineral resources, yet overall Asia is a net importer, unable to supply its own needs.

Overall, Asia is a net importer of metals. However, its known endowment and abundance of prospective settings indicate that Asia is capable of meeting all its mineral needs.

Asia is the youngest continent, a collage of blocks that came together over the past 15 million years. The blocks have long, complex histories, with different levels of erosion exposed, and different degrees of weathering. Ore deposit styles favour specific geologic or tectonic settings: as all settings are represented in Asia, all major deposit styles could be expected, and, indeed, are present with world-class examples.

Important gold deposits occur throughout Asia. The major tectonic sutures across central Asia host many orogenic gold deposits, source to huge placer gold fields. Epithermal gold deposits are important in the Pacific margin, and Carlin-type deposits are known in China and elsewhere. Important porphyry Cu-Au deposits are known in Central Asia and Mongolia, China and the Tethys belt. Sedimentary rock-hosted copper deposits are known in Russia and Kazakhstan. Major Zn-Pb deposits of various styles are known in India and Iran, China, Kazakhstan and Myanmar. Asia has two of the world's great sulfide Ni-Cu-PGE deposits in Russia and China. Important diamond deposits occur in the Siberian Craton, and other occurrences are known in the North China and Indian Cratons. Major deposits of iron ore, coal, lateritic nickel and many other commodities are also found in Asia. Its known endowment and abundance of prospective settings indicate that Asia is capable of meeting all its mineral needs.

Exploration in Asia has been patchy. Only in Indonesia and Turkey has modern western exploration been widely applied. In the former Soviet Union there has been extensive systematic exploration, but mostly focused on targets and commodities needed by the centrally planned economy. In China there has been extensive and intensive systematic exploration. However, throughout the region, even where there has been effective exploration, capital for development of discoveries has been lacking. Most of the region is either unexplored, ineffectively explored, or, at best, under explored.

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There are no geological reasons why Asia cannot make substantial contributions to world trade in most major mineral commodities.

The huge size of the Asian landmass would have been a factor in limiting exploration and development of mines, had most of it not been under the control of countries with centrally planned economies. In them, perceived need rather than economics drove exploration and development. With the collapse of that system, remoteness and availability of infrastructure has to be considered in determining where to explore, and for what. Topography and climate are also important, and strongly influence what deposits would be economically viable. But these factors, while important in making decisions about future activity, do not explain the inadequacy of Asian resource production.

The lack of privately funded exploration and development over past decades has resulted from political factors — particularly lack of access for exploration, and lack of security (legal, sovereign and physical), to encourage risk capital. In the past decade these aspects have improved through most of the continent, and continue to improve, though erratically.

There are no geological reasons why Asia cannot supply all its mineral needs and make substantial contributions to world trade in these commodities. The political and economic climate in Asia is improving for explorers and miners, and there is need for more supply from within the region.

Siberia and Mongolia:
How They Are Linked, and Their Role in Asian Mineral Potential

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The area of Russian Siberia and Mongolia roughly equals that of South America. Currently base metal, coal, Mo, Au-Ag, U and fluorspar mining is concentrated along the railway corridors in the south, whereas the remainder of the region produces gold, platinum, and diamonds, as well as nickel and copper.

The area of Russian Siberia and Mongolia roughly equals that of South America.

Tectonically, the Siberian craton is framed by the Neoproterozoic-Paleozoic Baikalide-Altaid orogenic collage to the west and north, Mongol-Transbaikalian collage to the south, and Mesozoic Circum-Pacific orogens to the east. The Neoproterozoic-Cenozoic sedimentary basins including Devonian and Permian-Triassic flood basalts overlap an Archean-Early Proterozoic basement of the craton. The orogens consist of several generations of Neoproterozoic to Mesozoic magmatic arcs and accretionary complexes that were deformed into oroclines during Paleozoic clockwise rotation of Siberia, and westward translation of the North China craton during the Late Paleozoic-Early Mesozoic. Development of the Mesozoic-Cenozoic sedimentary basins that obscure these orogens was controlled by continent-scale conjugate strike-slip faulting, caused by opening of the Canadian oceanic basin and subsequent southward collision of the Siberian craton. The Indian-Asian collision rejuvenated these faults, dismembering many continuous metallogenic belts and displacing their pieces by 70 to 400 km.

The region has produced more than 150 M oz of gold since the 19th century, mostly from placers. In the 1960-70s, giant (>30 M oz) orogenic (mesothermal) gold deposits (Sukhoi Log, Olimpiada), also a potential PGE source, were discovered in the Neoproterozoic black shale sequences at the craton margins. Black shales also occur in the magmatic arcs of southern Siberia (Zun Kholba deposit in Russia), highlighting their prospectivity in Mongolia. Medium-size (Pokrovskoe) and world-class (Baley) Au-Ag epithermal deposits formed during Mesozoic arc magmatism in belts extending from Russia to Mongolia. The Asgat (8,000t Ag) deposit in northwest Mongolia is a Paleozoic example. Magmatic arcs host low-grade hypogene Cu-porphyries, with the Erdenet deposit (Mongolia) currently in production. Discovery of the Oyu Tolgoi Cu-porphyry indicates that supergene and gold-enriched mineralization with economic potential is present. The craton and orogens also host Pb-Zn-(Cu) deposits of different ages and types (Ozernoe, Kholodninskoe, Gorevskoe, Rudny Altai).

The region has produced more than 150 M oz of gold since the 19th century, mostly from placers.

The Norilsk-Talnakh deposits in the northwest Siberian craton produce annually 20% of global Ni, 24% Pt, ~50% Pd, and 3.5% Cu.

The Norilsk-Talnakh deposits in the northwest Siberian craton produce annually 20% of global Ni, 24% Pt, ~50% Pd, and 3.5% Cu. They relate to the Permian/Triassic Tunguska flood basalts and are located at the triple junction of continental rifts generated by the Siberian super-plume. Plume-related mineralization is zoned with Cu-Ni-PGE at the center and a series of Fe-Ti and diamond deposits towards the margin. Some PGE production also comes from placers on the craton. Devonian to Cretaceous kimberlite pipes and placers on the craton support diamond production valued at US$ 1.62 billion (2000).

Although the region has an extensive geological database compiled during Soviet times, it remains under-explored and its excellent resources provide an opportunity for new discoveries if innovative techniques and ideas are employed (Oyu Tolgoi). Good potential exists for Bayan-Oboo and Olympic Dam-type mineralization. Cretaceous extensional structures in Mongolia and Russia host substantial uranium and fluorite deposits. In the southeast Siberian craton there are Carlin-style gold deposits (Kuranakh, 16 M oz) and terranes prospective for greenstone-hosted gold.

Although the region has an extensive geological database, it remains under-explored and its excellent resources provide an opportunity for new discoveries if innovative techniques and ideas are employed.

The remoteness of the land-locked region dictates that base-metal exploration will focus along existing rail corridors. Current high rail tariffs restrict exploitation of world-class thermal and coking coal deposits of southern Siberia, as well as development of the Udokan sediment-hosted Cu deposit (20 Mt Cu) and several Proterozoic Ni deposits (Ioko-Dovyrenskoe and Chiney) in the northern Transbaikalia of Russia. Many companies have investigated opportunities in the region with varying success. Several medium-scale gold projects (Kubaka, Zun-Kholba, Julietta, Pokrovskoe), developed with western financing, demonstrate that it is possible to work successfully in these challenging regions.

Metallogenesis
of the Russian Far East

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Recent developments in the Russian Far East show that economically viable joint ventures between Russian and non-Russian companies can be profitable for all parties involved.

Mining is often equated with frontier regions of the world, and the Russian Far East (RFE) is no exception. Since the late 19th century, RFE mineral output has included substantial quantities of gold, silver, platinum group elements, tin, tungsten, boron, fluorite, uranium, mercury, and antimony. Mineral exploration and development in the RFE predated the 20th century, but much of the large-scale mineral production activities took place after the establishment of the USSR. The development of the mineral resource industry in the RFE up to 1991 was due to the demand for minerals to augment the Soviet industrial base and, in the case of gold, to provide for foreign currency exchange. Frequently, mineral production was subsidized by government-planned development programs, and hence was not always economically viable. In the global economy of the 21st century, mineral development everywhere must withstand market-sustainable economic forces. Recent developments in the RFE (Kubaka Au, Julietta Au-Ag), show that economically viable joint ventures between Russian and non-Russian companies can be profitable for all parties involved.

Historical mineral production in the RFE is greater than 4,600 t of placer gold, and greater than 200 t of lode gold. Known gold resources exceed 3,000 t in some 17 deposits. From 1984 to 2000, platinum placer production from the Khabarovsk and Kamchatka-Koryak regions was approximately 56.3 t, mainly as iso-ferroplatinum. Production from both areas in 2000 was 7.1 tonnes of iso-ferroplatinum. Through 1992, at least 200,000 t of tin was produced from hardrock and placer sources, along with 59,000 t of tungsten. Lead, zinc and tin continue to be extracted from skarn deposits in the Primorye region of the southern RFE. Significant porphyry and stratabound copper resources occur in Chita, Magadan, and Chukotka. Two large open pit mines at Voznesenka and Dalnegorst in Primorye continue to be Russia's largest sources of fluorite and boron respectively.

The protracted tectonic development of the region, combined with a range of host terranes, from Proterozoic to Tertiary in age, has resulted in a substantial polymetallic mineral endowment.

The metallogenic evolution of the RFE occurred during Circum-Pacific accretionary tectonic events. Pre-accretionary mineralization includes: 1) mid-Proterozoic PGE-Ni-Cu resources in layered gabbro anorthsite complexes of the Lantarsky-Dzhugdzhur metallogenic belt; and 2) SEDEX and MVT Pb-Zn deposits hosted in Paleozoic continental margin sections in the Chukotka and Primorye regions. Syn- and post-accretionary metallogenic belts with significant gold and base-metal endowments include the Jurassic-Cretaceous Verkhoyansk, Yano-Kolyma, and Chukotka fold belts, the Cretaceous Mongol-Okhotsk and Okhotsk-Chulotka volcano-plutonic belts, the Cretaceous Sikhote-Alin arc, and the Tertiary Kamchatka arc. Mineralization is largely associated with thermal and deformational events along the northeastern Eurasian margin that occurred during continental accretion. Zoned mafic/ultramafic intrusions of the Ural-Alaska type, which are the source of significant placer PGE resources in the Konduer-Ignali and Koryak Kamchatka Belts, were emplaced during spatially separate, Jurassic and Late Cretaceous extensional events. Additional PGE-Ni resources in Kamchatka are also hosted in sill-form tholeiitic mafic intrusions of Triassic-Cretaceous age. The protracted tectonic development of the region, combined with a range of host terranes, from Proterozoic to Tertiary in age, has resulted in a substantial polymetallic mineral endowment.

Regional governments within the Russian Far East understand the importance of resource extraction and are pro-development.

More than 70 percent of Russia's fiscal revenues are currently derived from natural resources. Therefore, mineral development in the RFE will continue to be a critical aspect of the economic growth of the region. And because regional governments within the RFE understand the importance of resource extraction and are pro-development, the RFE is an attractive region for mineral development and production in the 21st century.

Mineral Potential of Central Asia:
What Do We Know?

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The Central Asian republics of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan intend to redefine their role both in the CIS and Asian markets, developing the mineral and energy resource potential of their national economies. The landlocked location of the Central Asian mineral provinces causes high infrastructure costs. Most transport routes are traditionally through Russia. One possible alternative is a Silky Way railroad project.

The mining industry in these five transition-economy countries plays an important role. In the past, the region served as a major metal provider for the FSU. Mineral products account for 1/3 to 1/2 of national GDPs from exports of gold (3.4 percent of the world's production in Uzbekistan (1996) and significant amount in Kyrgyzstan), ferrochrome (20 percent of the world's production in Kazakhstan), copper, lead, zinc, molybdenum, tungsten, niobium, tantalum, uranium, mercury, and antimony. In Turkmenistan, which focuses on the energy sector, and Tajikistan, processing imported bauxite with cheap hydroelectric power means that the mining industry plays a subordinate role. This is despite significant mineral resources of gold, silver, and copper in the Tajik Tien Shan and the Pamirs.

Mineral products account for 1/3 to 1/2 of national GDPs of the region from exports of gold, ferrochrome, copper, lead, zinc, molybdenum, tungsten, niobium, tantalum, uranium, mercury, and antimony.

The region is among the world's major Au producers, and hosts deposits such as Muruntau, Kumtor, Bakyrchik, and Vasilkovskoe.

Most ore deposits are confined to the Altaid orogenic collage, located between the East European and Siberian cratons and smaller Precambrian slivers. Several generations of arc magmatism contributed primarily to the ore potential of the Stans: Vendian to Early Paleozoic, Middle Paleozoic to Early Carboniferous, Early Carboniferous to Permo-Triassic. In the Mesozoic, there were several post-collisional magmatic events. The resulting tectonic-metallogenic belts are confined to the Kipchak arc, Kazakh-Mongol arc and its back-arc rifts, Valerianov-Beltau-Kurama arc, South Tien Shan – East Urals – Irtysh-Zaissan suture, Mugodzhar-Rudny Altai arc, and Sakmara suture.

The region is among the world's major Au producers. It hosts giant (>10 M oz) and medium to large orogenic (mesothermal) Au deposits of Muruntau, Kumtor, Bakyrchik, controlled by the South Tien Shan – East Urals – Irtysh Zaissan suture, granite-related Vasilkovskoe, Bestobe, Zholymbet deposits in the Kipchak arc, and Berezovskoe, Kochkar, Yubileinoe granite-related deposits in the Mugodzhar-Rudny Altai arc. Kochbulak, an important Au-Ag epithermal deposit,

The world-class Dzhezkazgan sediment-hosted Cu deposits are associated with Carboniferous red-beds, and PGE mineralization occurs in black shale-hosted deposits.

and low-grade hypogene Cu-porphyry deposits, with Au, Mo, and PGE by-products (Kounrad, Kalmakyr-Dalnee, Nurkazgan), are related to mid-late Paleozoic magmatic arcs of the region. The world-class Dzhezkazgan sediment-hosted Cu deposits are associated with Carboniferous red-bed aquifers. PGE mineralization occurs in black shale-hosted deposits (Muruntau) and in the porphyries (Bozshakol). Pb-Zn (Ag-Cu-Au) deposits (Maikain, Mizek, Tekeli, Shalkiya, Rudny Altai) are of different ages and types (VMS, sedex, sediment-hosted), with major production from Rudny Altai. Chromium deposits in Paleozoic ophiolites occur in the Kazakh Urals, related to the Sakmara suture (Kempirsai). Granite-related rare metal (Sn, W, Mo, Nb, Ta, REE) mineralization occurs in late-orogenic greisens, stockworks, skarns and pegmatites in Kazakhstan and Kyrgyzstan (Akchatau, Batystau, Verkhnee Kairakty, Aktiuz, Kalba). Significant U and V deposits of various types are present in Kazakhstan, Kyrgyzstan and Uzbekistan.

The region is still under-explored, and exceeds the size of Europe.

Regardless of the success of prospecting and exploration activities during Soviet time and since the 1990s, the region is still under-explored. This is a function of the complex geodynamic setting of this vast territory, exceeding the size of Europe, and is also related to continuing financial and legal difficulties. However, there are several operating mines with western investment. Despite the exploration maturity, this region is still able to generate new targets, especially in areas previously restricted or where attention is focussed under the Mesozoic-Cenozoic cover. Reassessing the conventional models of known deposits, such as mercury deposits of Kyrgyzstan or Fe-skarn deposits of the Torgai depression, can potentially lead to recognition of new deposit types. There is significant potential to develop known discoveries, such as lateritic nickel deposits in Kazakhstan.

Mineral Exploration in India:
The Perspective of Pioneering Juniors

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The overriding attraction of mineral exploration in India is its proven capacity to host world-class metal deposits, particularly those of Proterozoic and Archean age. India has several thousand years of history in mineral mining and refining and has rarely been far behind the technological leaders in the world. India is currently undergoing a steady philosophical shift in attitude to foreign participation in most of its industries and the doors are opening wider for non-Indian mineral explorers, miners and refiners. We review the mineral potential of India and present the experiences of Grenfell Resources, a junior exploration company, and of Mineral Deposits Limited, a miner of mineral sands.

India hosts several world-class mineral deposits. The Kolar goldfield produced 25 M oz. at an average grade of 16.0 g/t. The currently defined Panna diamond field is not large by world standards, but produces high-quality gems. The base-metal deposits in the Aravalli belt in Rajasthan are world class. The best known is Rampura Agucha with a resource of 66 Mt at 12.1% Zn, 1.7 % Pb and 30 g/t Ag, defined to a depth of 200m, below which the deposit is open. Iron ore is abundant in the northeastern states of Orissa and Bihar. India ranks fifth in annual world production and has reserves of over 10 Bt of high-grade haematite ore and 5 Bt of magnetite ore. The coastal mineral sands are phenomenal, with currently known resources (conservatively 200 Mt of ilmenite) ranking as the world's largest. There has been minimal exploitation of these deposits. India is also well endowed with chromite, bauxite, coal and manganese.

India has maintained the Mining Law regime established during British rule, and the recently revised regulatory system is parallel to that of Australia. While the systems are familiar, their implementation remains at an early stage, the main points of contention being the levels of Indian participation in development projects and uncertainty regarding requirements for state participation. A reasonable level of royalties set by the federal government and payable to the states has been in place for many years. Although implementation of the regulatory system is in its infancy, the system itself, combined with the strength of Indian law and democracy, should give comfort to all foreign companies.

India is currently undergoing a steady philosophical shift in attitude to foreign participation in most of its industries and the doors are opening wider for non-Indian mineral explorers, miners and refiners.

The Kolar goldfield produced 25 M oz at an average grade of 16.0 g/t. The currently defined Panna diamond field produces high-quality gems. The country ranks fifth in world production of iron ore.

The base-metal deposits in Rajasthan are world class. Rampura Agucha has a resource of 66 Mt at 12.1% Zn, 1.7 % Pb and 30 g/t Ag.

The case history of Grenfell Resources' foray into base metal and gold exploration in Rajasthan is one of achievement without discovery, and one of frustration with the global resources industry, rather than frustration with India. In summary, the securing of title has been straight forward, the conduct of airborne geophysical surveys has been expensive, but successful, and on-ground geochemical and geological operations have been effective and certainly no more complicated, strenuous or costly than in Australia. In two years our small team has evaluated a tenement package of over 10,000 square kilometres, revising regional geology and structure and defining prospect areas based on high quality aeromagnetics, substantial geological mapping and a range of modern geochemical techniques. The three principal prospects that will be reviewed are substantial in size. Each has compelling targets for drill testing, but Grenfell has been unable to attract sufficient funding to begin.

The experience of Mineral Deposits Limited (MDL) has been more fruitful. MDL was invited by a small Indian company (WSIL) to help develop the rich and extensive mineral sand deposits in Tamil Nadu. WSIL had secured certain government approvals to develop the deposits conditional on attracting appropriate technical and financial support. MDL, a long standing Australian sand miner, is providing this support in association with Iscor of South Africa and a full feasibility study for an integrated project is well under way.

Metallogenic Evolution
of the Western Tethys of Turkey and Iran

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Initial development of the Tethys Ocean commenced prior to the early Mesozoic Era, eventually occupying an area including the Mediterranean and southern Europe, North Africa, Turkey, Iran, and the Himalayan region. It effectively separated Laurasia from Gondwana and includes both the Palaeo- and Neo-Tethys oceans and their margins. Tethys occupied the general position of the Alpine-Himalayan orogenic belt between the Hercynian and Alpine orogenies, and was largely destroyed by the Alpine-Himalayan continental collision.

The western part of the Tethys belt (Balkans, Turkey, Iran, western Pakistan) is represented essentially by a composite magmatic arc, which extends from western Pakistan across Iran and Turkey and into eastern Europe. The arc began to form during the initial compression from Africa, with various subarcs being tectonically accreted to the Eurasian landmass during long lived compressional tectonics, with resulting subduction and obduction processes creating a complex but fertile metallogenic environment. The composite nature of the belt results from the superposition in time and space of diverse magmatic arcs, back-arcs and transitional tectonic environments.

Cretaceous subsidence of the continental margin created extensive platform shelf areas where carbonate-hosted lead/zinc/silver deposits such as Mehdiabad in Iran occur.

The earliest significant mineralization events of the western Tethys occurred during the Cretaceous, when volcanogenic massive sulfide and associated mineralization styles formed in marine basins in Eastern Europe, Turkey, and Iran. These include major deposits such as Cayeli in the Eastern Pontides of Turkey. Opening of the ocean caused subsidence of the continental margin, which created extensive platform shelf areas where carbonate-hosted lead/zinc/silver deposits such as Mehdiabad in Iran formed during the Lower-mid Cretaceous. Late Cretaceous obduction of oceanic crust at the collision sutures resulted in the formation of economically significant podiform chromite, manganese, asbestos and talc deposits throughout the western Tethys.

A second major metallogenic event occurred in the Late Cretaceous-Paleocene when numerous porphyry systems intruded the older VMS terrains in regions where they had been accreted or approached the magmatic arc. Examples include Demirkoy in the Thrace region of Turkey and numerous Cu skarn centres in southern Bulgaria. Similar mineralizing events in the Eocene-Oligocene epochs resulted in the formation of numerous porphyry copper/molybdenum/gold systems in the eastern Pontides such as Gumashane, along with centres of epithermal mineralization.

Miocene continental arc-style tectono-magmatism formed large porphyry Cu-Mo-Au deposits at Sar Cheshmeh and Sungun in Iran, and Reko Diq and Saindak in western Pakistan.

A major mineralizing event occurred in the Late Oligocene-Miocene epochs, as a consequence of continental arc-style tectono-magmatism. This resulted in the emplacement of large porphyry copper/molybdenum/gold deposits at Sar Cheshmeh and Sungun in the Uromieh-Dohktar belt in Iran, and the Reko Diq and Saindak deposits in Balochistan in western Pakistan. This zone extends through Turkey and into the Balkans as the north Anatolian Metallogenic Belt. Epithermal gold deposits were also formed at this time, particularly in west Anatolia within zones of regional extension.

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Important mineralization styles in the Pliocene-Quaternary epochs are the Turkish world-class borate and trona deposits in Quaternary age basins. Late hydrothermal mineralization includes alunite and kaolin deposits in Iran, and probably formed sediment-hosted gold mineralization at Takab.

Recent changes and improvements to mining and fiscal legislation in Turkey have resulted in a relative increase in exploration activity and expenditures by foreign companies. Iran has yet to attract similar levels of foreign investment.

Mineral Potential
of China

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China is rich in mineral resources with a total potential value of >US$11 trillion, ranking third in the world. Comprehensive geological surveys at various scales, launched in 1950s, have resulted in the discovery of 171 mineral commodities, with proven reserves being established for 156 commodities. More than 200,000 metal and industry mineral deposits and occurrences, including 25,000 sizable and 87 giant deposits, have been identified in various parts of the country. A significant mineral potential remains to be discovered, particularly in the largely unexplored area of western China.

The important deposit types include: 1) magmatic Cr, Ni-Cu-PGE, Ti-V, REE-rare metals; 2) porphyry-epithermal Cu-Mo-Au-Ag; 3) skarn Cu-Au-Pb-Zn-Sn; 4) granite-related REE and rare metals; 5) volcanogenic massive sulfide (VMS) Cu-Zn-Pb-Au-Ag; 6) sedimentary exhalative (Sedex) Pb-Zn-Cu-Ag-Sn; 7) Mississippi Valley-type (MVT) Pb-Zn; 8) sediment-hosted Cu-Pb-Zn-Sb-Hg-Al-Mn-Sr-Ba; and 9) orogenic Au-Ag deposits. The magmatic Cr deposits are hosted by ultramafic-mafic rocks in suture zones of the major orogenic belts. The magmatic Ni-Cu-PGE and Ti-V deposits are associated with ultramafic-mafic intrusions or mafic volcanic rocks at the margins of Sino-Korean and western Yangtze platforms, and in the Altaides of northwest China. Porphyry-epithermal and skarn deposits occur mainly in the Yanshanian volcanoplutonic belt, Tianshan orogenic belt and the Himalayan-Tethysides. Most VMS deposits occur in the Paleozoic-Mesozoic orogenic belts of western China; several occur in Archean to Proterozoic metamorphic volcanic rocks in basement rocks of the Sino-Korean and Yangtze platforms. MVT, Sedex and sediment-hosted deposits are associated with Proterozoic sequences along the northern margin of the Sino-Korean platform and in Late Paleozoic units of the Yangtze platform. Orogenic gold deposits have been found mainly in the western Qinling and Golden Triangle belts along the western portion of the Yangtze platform and in the Tianshan belt, northwest of the Tarim platform. China is particularly rich in rare earth and rare metal (Nb, Ta, W, Sn, Sb, Bi, Li and Be) deposits that are mostly associated with carbonatites on the northern margin of the Sino-Korean platform and granites of the Yangtze platform. In addition, China has an abundant resource of industrial minerals (e.g., fluorite, magnesite, mirabilite, bentonite, asbestos, talc, graphite, gypsum/anhydrite and vermiculite) that occur in various tectonic units.

Recent exploration has identified a number of important metallogenic belts in western China.

The geological setting of the Tethysides and Altaids in western China provides favorable targets for VMS, Sedex, MVT and porphyry-epithermal exploration.

Most flysch belts in the two orogenic systems remain under-explored, and the potential to discover large orogenic Au and sediment-hosted PGE deposits is high.

Most of the deposits were identified during the past two decades, and new discoveries of significant potential are reported every year. In particular, recent exploration has identified a number of new, important metallogenic belts in western China, which includes the eastern Tianshan porphyry-Cu belt (Xingjiang), the Gandese porphyry-epithermal Cu-Au belt (Tibet), the western Qaidam sediment-hosted Cu-Co belt (Qinghai), the Zhongdian porphyry Cu belt (Yunnan), the Baiyangping sediment-hosted Cu-Ag-Pb-Zn belt (Yunnan) and the Minle volcanic redbed Cu belt (Yunnan). Further exploration using advanced technology is required in many metallogenic belts. The paleo-rift belts along the margins of the Sino-Korean, Yangtze and Tarim platforms provide potential targets for magmatic Ni-Cu-PGE deposits. Significant potential for diamond, Fe-oxide (possibly Olympic Dam-type) and sediment-hosted base and rare metal deposits exists in the platforms. There is considerable potential for porphyry-epithermal Cu and Au deposits in the Yanshanian volcanoplutonic belt. The geological setting of the Tethysides and Altaids in western China provides particularly favorable targets for VMS, Sedex, MVT and porphyry-epithermal exploration. Most of the flysch belts in the two orogenic systems remain under-explored, and the potential to discover large orogenic Au (possibly Muruntau-type) and sediment-hosted PGE deposits is high. The redbeds developed in the Jurassic to Tertiary intracontinental basins in western China possess significant potential for large Cu-Ag-Au-Pb-Zn deposits. Exploration has been intensified since 2000, when the Chinese government allocated massive funding increases and promulgated new policies for the development of western China.

Exploration has intensified since 2000, when the Chinese government promulgated new policies for the development of western China.

An Overview
of the Mineral Resources of the Indochina Region

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The Indochina region occupies the southeast corner of the Asian continent. This presentation will discuss Myanmar, Thailand, Cambodia, Laos, Vietnam and Yunnan Province. Indochina has a long, complex and poorly understood geologic and tectonic history. The oldest rocks in the region are late Archaean metamorphics in southern Yunnan. Proterozoic basement blocks are exposed in central Vietnam, the Yunnan Golden Triangle and Mogok in Myanmar. The oldest well-established orogeny is the Triassic to early Jurassic Indosinian event related to early Mesozoic collisions and amalgamation of the three or four continental fragments that comprise southeast Asia. Major Tertiary strike slip faults (Sagaing in Myanmar and Red River in Vietnam and Yunnan) are related to widespread extension.

Indochina has diverse mineral resources that have been exploited for thousands of years. One of the earliest mining sites was located in the central Mekong River Basin where Bronze age smelters processed copper and iron from porphyry copper-related skarns at Phu Lon in Thailand and tin ores from Nam Pathene in nearby Laos. Much later, during the 9th to 12th centuries, Khmer civilisations established at Angkor Wat and Bagan were dominant metal processing and gem trading centres for all of southeast Asia. Substantial alluvial gold has been produced throughout the region during the past millennium. The famous Bawdwin mines in Myanmar supplied the region with silver from the 15th century, much of which was used as currency for trading. Colonial French and British mining interests arrived in Indochina in the late 1890s to develop gold deposits in Vietnam and Thailand, tin in Laos and silver-lead in Myanmar. Most mineral production after 1960 has been dominated by Thailand, where significant tin-tungsten and industrial minerals such as antimony, fluorite and baryte were exploited.

In recent years significant developments include the Monywa copper deposit in Myanmar, the Padaeng zinc mine and the newly commissioned Chatri gold mine in Thailand. Because of more favourable minerals policies, exploration activities have increased throughout the region with the notable exception of Cambodia. Unfortunately, geo-politics has to some extent dictated where mining companies are willing to invest in Indochina.

Because of more favourable minerals policies, exploration activities have increased throughout the region.

Indochina is relatively unexplored in terms of exploration drill-based expenditures when compared to neighbouring countries. Potential exists for a wide range of commodities and mineral deposit types.

Potential targets include VMS and MVT lead-zinc deposits, porphyry copper-gold environments in, sediment-hosted gold and copper deposits, and diamond possibilities.

Advanced projects in Laos are the porphyry-related copper-gold deposits at Xepon (Oxiana NL) and Phu Lek (Pan Aust NL). BHP-Billiton are evaluating the very large sediment-hosted Lanping zinc deposit in Yunnan. Significant exploration in Vietnam is being conducted by Olympus at their Phuoc Son mesothermal vein gold project, and by Tiberon at the Nui Phao polymetallic tungsten skarn. Exploration in Thailand is minimal at present with some activity in the Loei district for copper (Pan Aust NL), zinc (International Annex at Baw Hin Khao) and gold (Equatorial Gold). The very large Udon Thani potash deposits continue to be evaluated by Asia Pacific Minerals. In Myanmar, Ivanhoe Mines Ltd. is conducting advanced exploration at their Momi Taung mesothermal vein gold project.

Indochina is relatively unexplored in terms of exploration drill-based expenditures when compared to neighbouring countries such as Indonesia and the Philippines. Potential exists for a wide range of commodities and mineral deposit types. The Indochina region is still perceived to be high risk by the international mining community and future exploration will be dictated by foreign investment, minerals policies, and commodity prices. Potential targets include VMS and MVT lead-zinc deposits in Myanmar, Thailand, Vietnam and Yunnan, iron oxide copper-gold models in Yunnan and Vietnam, porphyry copper-gold environments in Yunnan, Laos, Thailand and Cambodia, sediment-hosted gold and copper deposits in Yunnan, Laos and Thailand, and diamond possibilities in Yunnan and Vietnam.

Geologic Setting, Style and Discovery Potential
of Gold and Copper Deposits in Indonesia and the Philippines

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Gold and copper mineralization in Indonesia and the Philippines is localized within middle to late Cenozoic (30 Ma to 1 Ma) magmatic arcs. The common deposits belong to porphyry, skarn, high- and low-sulfidation epithermal, disseminated sedimentary rock-hosted and volcanogenic massive sulfide deposit styles. The combined past production and current resources of these deposits exceed 8,300 t gold and 60 Mt copper. The majority of the gold is contained in porphyry (~65%), low-sulfidation epithermal (~15%) and skarn (~10%) deposits.

The combined past production and current resources of Cenozoic deposits exceed 8,300 t gold and 60 Mt copper.

Fourteen major magmatic arcs of Cenozoic age form a complex border to the Sundaland craton of the Eurasian Plate and the northern margin of the Australian platform. This volcano-plutonic chain extends >12,000 km from Taiwan in the northeast, through the Philippines and Indonesia, to Myanmar in the northwest. The arcs are constructed on basement formed from oceanic and continental crust. The geometries of individual arc segments are complex and the product of subduction, locally involving polarity reversals, obduction, arc-arc and arc-continent collisions, rifting and transcurrent faulting.

The largest gold and copper deposits in Indonesia and the Philippines form clusters along short sectors of Plio-Pleistocene arcs. The primary reason for the abundance of gold deposits of this age is probably related to erosion. In late Quaternary arcs, uplift and erosion have not exposed mineralized systems. By contrast, erosion has largely removed potentially economic deposits in Cretaceous and early Paleogene arcs. The abundance of large deposits in the Plio-Pleistocene is attributed to the localization of magmatic and structural events during a plate tectonic reorganization, initiated by the 5 Ma collision of the Philippine Sea Plate with the Eurasian Plate near Taiwan. The collision of the Australian platform with the Banda arc in eastern Indonesia at 4 Ma to 3 Ma is also inferred to have had a role in deposit genesis.

The largest gold and copper deposits in Indonesia and the Philippines form clusters along short sectors of Plio-Pleistocene arcs.

Gold and copper deposits in Indonesia and the Philippines are spatially and temporally related to intrusions and volcanic centers. Regional transcurrent faults localized mineral deposits in oblique- and orthogonal-convergent tectonic settings. Porphyry, skarn and high-sulfidation epithermal deposits are closely related to shallow intrusions. Low-sulfidation epithermal systems are located within, or adjacent to, volcanic centers and locally associated with diatreme settings.

There is excellent potential to discover additional gold and copper deposits in regions of crustal weakness, as indicated by the distribution of arc-transverse faults and igneous centers.

The mining law of each country allows foreign companies to hold as much as a 100 percent stake; however, better chances of success exist for those companies that form local partnerships.

The local distribution of several of the deposit styles reflects differences in tectonic setting and the composition of crustal basement. The magmatic arcs in western Indonesia, which overlie continental crust of the Sundaland craton, primarily contain low-sulfidation epithermal deposits. These low-sulfidation systems lack an obvious link to causative intrusions. In contrast, those magmatic arcs in eastern Indonesia and most of the Philippines, which overlie oceanic crust, contain intrusion-related porphyry and high-sulfidation deposits as well as low-sulfidation systems. This may indicate higher levels of intrusion emplacement contemporaneous with mineralization in arc sectors that overlie thin oceanic basement than arcs that overlie thick continental crust. The exception to this correlation is the Medial Irian Jaya arc, which formed on the northern margin of the Australian platform and contains the Grasberg porphyry-Ertsberg skarn complex. In this arc, regional arc-transcurrent strike-slip faults, active during Neogene foreland fold- and thrust-belt development, may have acted as conduits for ascending magma and mineralizing fluids, and allowed the emplacement of the causative intrusions at higher levels than in arcs constructed on the Sundaland craton.

There is excellent potential to discover additional gold and copper deposits in both countries, particularly in Plio-Pleistocene arc sectors in regions of crustal weakness, as indicated by the distribution of arc-transverse faults and igneous centers. The mining law of each country allows foreign companies to hold as much as a 100 percent stake; however, better chances of success exist for those companies that form local partnerships.

Nonferrous Exploration and Investment Trends in Asia

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According to the 12th edition of Metals Economics Group study *Corporate Exploration Strategies*, worldwide exploration budgets in 2001 were at their lowest level since 1992. This presentation will examine exploration trends worldwide and in Asia over the past five years, highlighting where mining companies are exploring and what commodities they are targeting.

We will also discuss the other main vehicle for growth in the industry – acquisitions. How has acquisitions activity related to exploration activity over the last few years? We'll take a quick look at the relative levels of each and discuss some of the most important influences affecting them, including commodity prices, the markets, and changing corporate strategies for growth.

Worldwide exploration budgets in 2001 were at their lowest level since 1992.

The most important influences affecting exploration trends and acquisitions are commodity prices, the markets, and changing corporate strategies for growth.

Mining Reform
and its Relationship to Exploration Investment Worldwide

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A key trend in the mining sector during the 1990s was the significant increase in foreign direct investment by international mining companies in developing countries, to the stage where it became the main source of financing for mineral resource development. This trend occurred in response to opening of economies in general and the mining sector in particular to foreign private investment. Past surveys indicate that government policies and stability play a key role in investment decision-making of mining companies, second only to geological conditions. Some countries have successfully reformed or are reforming their mining sector, while the efforts of other countries continue to stagnate. The World Bank Group Mining Department and the Metal Mining Agency of Japan recently conducted a global survey to evaluate the implementation of mining sector reform in all regions of the world, in order to provide governments with information on the relationship between such reform and private mineral investment.

Mining reform has been more successful in countries that undertook a comprehensive approach, including legal, fiscal, institutional and enterprise reform, together with the development of appropriate environmental regulations. The more successful mining sector reforms have been preceded by or have been part of broader nationwide economic reforms that liberalized the regime for private investment generally (including revision of taxation, banking, trade, foreign exchange, and labor laws and regulations). During the initial stage of mining sector reform, significant fractions of new private investment went into acquisition and restructuring of existing mining operations (e.g., Tintaya, Peru) or into advanced exploration projects (e.g., Escondida, Chile, Yanacocha, Peru, Bajo de la Alumbrera, Argentina, Geita, Tanzania). These initial projects were important to generate an exploration boom, as successful projects increased the awareness within the mining industry of both the reform progress and the geological prospectivity of the country. As governments advanced in the implementation of mining reforms, major investments were made in grassroots exploration, eventually targeting commodities other than precious metals, dramatically increasing the number of projects.

Mining reform has been more successful in countries that undertook a comprehensive approach, including legal, fiscal, institutional and enterprise reform.

Most variation in the results achieved by countries that have successfully reformed can be explained by differences in geology, mining tradition and geography. Group A consists of highly prospective countries for which high quality geological information is readily available, that are not landlocked, and that have a long mining tradition, including Chile, Peru, Mexico, Brazil, and Indonesia. These countries attracted large amounts of investment in 1997, ranging from approximately US$ 150 to 230M. Group B countries have attractive

Most variation in the exploration attracted by countries that have successfully reformed can be explained by differences in geology, mining tradition and geography.

geology, but reliable information is not as readily available, due either to a lack of mining tradition or to a long period of reliance on state-owned enterprises that did not carry out much exploration. In addition, they either lack a mining tradition or are landlocked, such as Argentina, Tanzania, and Zambia. Group C countries have limited to high prospectivity and geological documentation, and have either a mining tradition or a coastline, but not both, including countries like Bolivia and Madagascar. Their lack of success in attracting exploration investment may also relate to other issues, such as political instability, country macroeconomic policy, public security, level of corruption, labor problems or inopportune timing of reforms.

Long-term success in attracting exploration investment includes effective implementation of policies to adapt a country's legal, fiscal, and institutional framework to the challenges of competitive global markets for capital and mineral products.

Long-term success in attracting private investment in exploration depends on a combination of favorable factors. This starts with natural endowment but includes effective implementation of policies to adapt a country's legal, fiscal, and institutional framework for development of the mining sector to the challenges of competitive global markets for capital and mineral products. Countries with favorable geology can achieve a dramatic increase in their share of worldwide exploration investment by implementing a package of policy changes, especially if they have a mining tradition and/or are not landlocked.

Asian Mineral Resources:

Exploration, Investment and Management Strategy In China and Adjoining Countries

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Mineral exploration has expanded considerably in Asia. Although the recent downturn in commodity prices has also hit this region, the geographic focus has shifted more than a major decline in the expenditure level. Five years ago the southeast Asia region was the major centre of exploration focus in Asia, with gold and base metal mining operations being developed, particularly in Indonesia and adjacent Papua New Guinea. The financial crisis that hit the region in late 1997 resulted in a rapid decline in investment confidence across the entire economic sector, including mining. As a consequence, exploration funding has been directed increasingly into the more stable and faster growing, major economy offered by China. In addition, there have been smaller programs in adjoining countries including India, Thailand, Laos, Vietnam and the Philippines, where an indigenous or more recently established mining industry exists, or at least seems possible, with advanced projects in Laos and Vietnam. Other adjoining countries that lack any established foreign investment or only have a few isolated projects in production include Myanmar, North Korea, Malaysia and Mongolia. The first two have military governments in general considered hostile to foreign investment. The following criteria are fundamental to the success of mineral exploration in this region:

1) Natural resource endowment: Is there convincing evidence of major metalliferous deposits or an established mining industry.
2) Government attitude towards mining and exploration: Evidence of successful investment in minerals exploration, discovery and development through exploration licenses and mining leases, with a capacity to achieve a return on invested capital. This includes favourable tax royalty and open-market sales of products.
3) Availability of skilled geoscientists: People who can be employed to conduct mineral exploration and project evaluation.
4) Availability of service contractors: Provision of drilling, assaying, engineering and metallurgical testing, and geophysical and remote sensing contractors.
5) Infrastructure: Availability of rail, roads, power and community services.
6) Environmental, social and political climate: Recent examples of problems in this area include the closure of the Bouganville copper deposit in 1989, pressure on Ok Tedi from land claims related to the tailings situation, growing unrest in Indonesia which has affected the Mesel and Kelian gold projects, and informal mining which has damaged other gold operations and coal deposits in Kalimantan.

The geographic focus in exploration has shifted from southeast Asia to China, more than a major decline in the expenditure level.

The Practicalities of Working In Asia:
A Management Perspective

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Working in Asia can be a very challenging but rewarding experience, and the experiences can vary from the sublime to the ridiculous. The challenges are many and rooted particularly in the cultural differences between east and west that can be perplexing and frustrating, with occasionally seemingly insurmountable barriers which defy even the most experienced professionals. These frustrations can be particularly exacerbated in remote places where most natural resource projects are discovered and developed.

Purpose and persistence, but also patience, are required to approach these problems and a successful programme will depend to a large extent on the quality of the people involved in the activities on both sides. Their training, their ability to listen, learn and integrate will be fundamental to a successful outcome. Negotiating agreements in a win-win mode is a very real challenge in an environment where most people learn to negotiate from birth! Being a good geologist or mining engineer is generally not good enough, and for the investor to be successful, the professionals in the field should have a marked potential for absorbing cross-cultural management experience or have these skills already to hand.

Purpose and persistence, but also patience, are required to approach these challenges of working in Asia, and a successful programme will depend to a large extent on the quality of the people involved.

A meeting of minds on the objectives and likely outcomes of the business venture between the host-country joint venture partner and the foreign investor is one of the most important starting points for any programme. To quote an oft-cited Chinese saying 'it is no good being in the same bed with different dreams'. Choice of partner, from both points of view, is a fundamental step on the road of success or failure.

Persistent determination and long-term commitment is both expensive and time consuming, and this in itself provides limits to the involvement of individuals and juniors in difficult market times. Larger companies also have their limits however. As local executives learn more about their environment and its customs and practices, it is easy to forget that 'head office' has not participated in this rich learning process. A widening perceptions gap can easily arise if communication is not intense and constant.

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Being a good geologist or mining engineer is generally not good enough. For the investment to be successful, the professionals in the field should have a marked potential for absorbing cross-cultural management experience.

Although there are many barriers and obstacles to success, things are getting a little easier. In China the past 20 years of the open-door policy is now breeding a new generation of entrepreneurs and educated professionals that can facilitate and enable more international business practice in the future. Equally westerners are becoming more familiar with eastern culture as globalisation becomes a real phenomenon.

The presentation will try to give a flavour of the practicalities of working in Asia, but with particular reference to China where the author is currently located.

Biographies of co-chairmen and speakers

Co-Chairmen

Dr. Koh Naito is the Principal Officer for International Partnership in the International Affairs Department of the Geological Survey division of AIST in Japan. Prior to this he was a geologist with the Metal Mining Agency of Japan for 12 years, during which time he conducted research and published on the Hishikari and Kamioka mines. While working for MMAJ he was seconded to JICA to work on aid projects throughout Asia and Africa. Most recently he spent three years with the Mining Department of the World Bank in Washington, again working throughout Asia and Africa, with responsibility for the technical review of World Bank lending. He has worldwide expertise on the regulatory framework for mineral exploration, and has published extensively, including two books summarizing his recent World Bank research on the topic.

Mr. Wayne Spilsbury is currently General Manager, Exploration in the Asia-Pacific region for Teck Cominco, based in Perth. He established a regional presence for Teck Corporation in Asia through joint ventures in Indonesia, Vietnam and China. He was a founding member of the executive team for PacMin Mining Corporation and Indochina Goldfields (now Ivanhoe Mines), and was also Vice-Chairman of the Board to the Mineral Deposits Research Unit at the University of British Columbia.

Professor Shunso Ishihara has had a long career with the Geological Survey of Japan, becoming Director before being elevated to the position of Director-General of the parent Agency of Industrial Science and Technology. On retirement from government he became professor at the University of Hokkaido, and he is now Scientist Emeritus and Senior Advisor to the Geological Survey division of AIST. Anyone who has used the magnetite-type and ilmenite-type granite terms, or has mapped with the aid of magnetic susceptibility, will be familiar with his work. He was Vice President of the Society of Economic Geologists for Asia, and has received the SEG Silver medal.

Mr. Hugo Dummett is Executive Vice President, Exploration for African Minerals, and also Executive Vice President, Project Development for Ivanhoe Mines. Previously he was Senior Vice President Exploration for BHP Minerals Discovery. While he was Exploration Manager North America for BHP, he established a joint venture with Diamet that led to the eventual development of the Ekati diamond mine in Canada. He is presently President of the Society of Economic Geologists.

Dr. Jeffrey W. Hedenquist coordinated the MMAJ Forum on Mineral Potential of Asia. He is an independent economic geologist, based in Ottawa, Canada, with a worldwide consultancy. From 1979 through 1998 he worked for 10 years each with the Geological Survey of Japan and the DSIR Chemistry Division, New Zealand, where he conducted research on active hydrothermal systems as well as epithermal and porphyry ore deposits around the Circum Pacific. He was recently awarded the SEG Silver medal, and is now the SEG Vice President for Regional Affairs.

Speakers

In addition to the following 14 speakers, 20 co-authors contributed material to the presentations.

Mr. Naotoshi Sugiuchi is the Executive Director of International Affairs for the Metal Mining Agency of Japan, Tokyo. He has a long career with the Ministry of Foreign Affairs, with overseas postings.

Dr. Noel White graduated BSc Newcastle NSW, and PhD Tasmania. He worked most of career with BHP Minerals in the Exploration Division, with positions including various operations roles exploring for a range of commodities, research geologist and finally as the BHP Chief Geologist. Apart from operations in most parts of Australia, for the past 20 years most of his work has been international, with experience in 43 countries, including most Asian countries, and he had periods based in London and San Francisco. Noel left BHP in 1999 and is now a consultant based in Brisbane. His current activities include Technical Editor for the Society of Economic Geologists Newsletter, and he is Vice-President-Elect for Regional Affairs of SEG. He is also on the Editorial Boards of Mineralium Deposita and Geology, and is a Research Associate at the Natural History Museum, London, and the Universities of Tasmania and Auckland.

Dr. Alexander Yakubchuk is a consulting economic and regional geologist, and is also a scientific associate at the Centre for Russian and Central Asian Mineral Studies, Natural History Museum, London. From 1994 to 1999, he was a project geologist and branch manager of the BHP Minerals' Russian Far East and South China programs. Prior to that he worked at the Istanbul Technical University on the Altaid Project of Prof. A.M.C. Sengor. He was associated with the Faculty of Geology, Lomonosov Moscow State University from 1986 to 1994, first as a student and finally associate professor. He has worked extensively in the Russian Far East, South China, Ukraine and Kazakhstan. Sasha was one of the four prize winners of the Gold Corp challenge in 2001, receiving USD $75,000 for his interpretation of the Red Lake property and identification of drilling targets for new gold discoveries. He has published extensively on tectonics, metallogenesis and ore deposits of Asia.

Dr. Lance Miller has worked throughout the Russian Far East as well as in China on mineral exploration projects. He was Projects Manager – Eurasia for Placer Dome from 1997-1999, which included an evaluation of the Sukhoi Log deposit in 1998. From 1988-1997 he worked for Echo Bay Mines in the western US and Mexico, and was Chief Geologist of the AJ Project in Alaska. He co-edited the Economic Geology Monograph #9 on the mineral deposits of Alaska, and was editor of a recent Russian publication on the placer gold deposits of Northeast Russia. Lance is now the Executive director of the Juneau Economic Development Council in Alaska, and has visited provinces in the Russian Far East to improve economic relationships.

Dr. Reimar Seltmann graduated from the Technical University (Mining Academy) in Freiberg/Saxony (East Germany) where he specialized in exploration geology. His PhD thesis addressed decision-making criteria during prospecting of rare metals (Sn, W) in the former Eastern block and aspects of resource evaluation. From 1987 he worked as team leader at the Central Institute for Physics of the Earth of the East-German Academy of Sciences and specialized in the metallogeny of porphyry breccia pipes. In 1992, at the new GeoResearchCenter (GFZ Potsdam), he shifted his research to granite-related metallogeny and published on textures in rare metal granites. He was a visiting research fellow at the Geological Survey of Canada and at Carleton University Ottawa (1995-1997). Since 1999 he has worked as a petrologist at the Natural History Museum in London (UK), where he initiated and coordinates as Director the newly formed Center for Russian and Central Asian Mineral Studies (CERCAMS). Reimar is the leader of the IGCP project #373 on "Anatomy, textures and magmatic-hydrothermal transition processes of ore-bearing felsic systems in Eurasia" and has produced a number of monographs, metallogenic maps and reference guidebooks about metal provinces of the former Soviet Union. He has also led several field trips to Uzbekistan, Kyrgystan, Russia (Urals, Sikhote Alin) and Kazakhstan for IAGOD and SEG.

Dr. David Isles is a geophysicist who has specialised is airborne methods in mineral exploration applications.After completing a PhD project on the Broken Hill region in New South Wales, he spent 7 years with BHP Minerals in Australia, then 7years with World Geoscience on large international airborne survey projects. In 1993 he joined a group of industry colleagues to form and operate small exploration and mining companies. He is currently the Exploration Director for Grenfell Resources Ltd, one of the companies resulting from this enterprise, and they are active in the exploration for and development of mineral sands and sediment-hosted base metal deposits in India with local partners. Grenfell Resources has the proprietary rights to the BHP-Billiton airborne gravity system, Falcon, in Australia.

Mr. Peter Leaman assumed the role last year of Global Assessment Leader Base Metals for BHP-Billiton Minerals Exploration. Prior to that he held a number of senior technical and exploration management positions for BHP in Asia from 1994, managed from Hong Kong. This included management of the southeast and west Asian porphyry copper exploration programs. Peter led the team which discovered the Reko Diq porphyry copper deposit in Pakistan, and the Ofi Creek porphyry copper and Crater Mountain gold deposits in Papua New Guinea. He worked extensively in the early 1990s in Iran, and his co-author, Dr. John-Mark Staude, presently has an active exploration project in Turkey.

Dr. Kaihui Yang has been working as an economic geologist in various parts of China and eastern Canada. After 10 years with the former Ministry of Geology and Mineral Resources (now the Ministry of Land and Resources) in China, he came to Canada as an international fellow of NSERC (Natural Science and Engineering Research Council of Canada) in 1993. Since then, he has worked as a research associate at the University of Toronto, and as an independent consultant for a number of western major and junior mining companies, especially on their projects in China. Kaihui has published widely on a number of ore deposit styles in China, and he remains closely involved with Chinese academic and industry colleagues.

Mr. Douglas Kirwin is the Executive Vice President, Exploration, of Ivanhoe Mines, a moderate size mining company based in Vancouver. They operate the Monywa Cu mine in Myanmar, and are developing the Oyu Tolgai porphyry Cu deposit in Mongolia, plus have a gold deposit in Uzbekistan. Doug has 30 years international exploration experience and much of the past 20 years has been spent in the southeast Asian region. He is based in Thailand and is currently involved in advanced projects in Mongolia, Myanmar and South Korea.

Dr. Steve Garwin obtained a B.Sc. degree from Stanford in 1984, a M.Sc. from UBC in 1987 and a Ph.D. from the University of Western Australia in 2000. Steve has 13 years experience as an exploration geologist in South East Asia, particularly in Indonesia and the Philippines. He has been employed by Newmont Mining Corp. for the last 9 years and joined the Nevada exploration and mine geology group as chief geologist in September of 2000. He is also Adjunct Researcher at the Centre for Global Metallogeny, University of Western Australia, and has published on the major new discovery of the huge Batu Hijau porphyry Cu-Au deposit in Indonesia.

Mr. Bakes Mitchell has had a classical education in liberal arts and the law. He has been a research analyst with Metals Economics Group of Halifax, Nova Scotia, since 1992, the most widely respected company that examines world wide trends in exploration investment. He is currently a senior consultant to Metals Economics Group and shares responsibility for marketing and sales.

Mr. David Tyrwhitt has a long career in exploration in the Pacific and Asia, rising to the positions of President of Newmont Australia and CEO of Ashton Mining. For the past 8 years he has been a management consultant with extensive experience in China and other Asian countries, including North Korea, Indonesia and India.

Mr. Nigel Clark, originally trained as a geologist in the UK, worked overseas for 29 of the past 30 years while employed by Billiton, and then by BHP-Billiton until 2001. He has held a number of management positions in exploration and development in various countries and has also managed underground and open-pit mines while in Indonesia, including the Lerokis gold deposit on the island of Wetar in Nusa Tengara Timur. Nigel now works as an independent consultant and is currently resident in Beijing, China. He has been a standing committee member of the British Chamber of Commerce in China for the past three years and is the chairman of their Western Provinces Committee.

References

A brief and incomplete bibliography on the geology and mineral potential of Asia, including publications referred to in presentations

Websites:

British Natural History Museum Centre for Russian and Central Asian Mineral Studies / CERCAMS: http://www.nhm.ac.uk/mineralogy/groups.htm

British Natural History Museum European Union-funded Urals research network and related links: http://www.nhm.ac.uk/mineralogy/minurals/minurals.htm

Department of Mineral Resources of Thailand: http://www.dmr.go.th/

Central Asian links, such as Kyrgyzstan SEG-IGCP field conference 2001:
http://www.nhm.ac.uk/mineralogy/seltmann/IGCP/Kyrgyz2.htm
http://www.nhm.ac.uk/mineralogy/seltmann/IGCP/Kyrgyzlinks.htm
YugGeo ATLAS project: http://www.yuggeo.nursat.kz/
Central Asia Resource News (CARN): http://home.istar.ca/%7Ejmenzies/research/
http://home.istar.ca/%7Ejmenzies/research/tien-shan-geology_cole.htm

Geological Survey of India: http://www.gsi.gov.in/

Geological Survey of Iran: http://www.gsi-iran.org/

Geological Survey of Japan: http://www.aist.go.jp/GSJ/HomePage.html

Geoscience Interactive Databases (v1.0c) – Cornell University /INSTOC: http://atlas.geo.cornell.edu/ima.html

Mineral resources map of Asia, Kamitani, M., and Naito, K., editors, 1998, Metal Mining Agency of Japan, Scale 1:10,000,000, with tables and html CD-ROM, or on line: http://www.mmaj.go.jp/mric_web/deposit/index.htm

Turkey MTA data base: http://www.mta.gov.tr/harita/hrtturk.htm

US Geological Survey data base: http://edcdaac.usgs.gov/gtopo30/hydro/europe.html

USGS Open-file reports: ftp://geopubs.wr.usgs.gov/pub/open-file/of99-165/MINDEP/

Maps:

Chen Yuchuan (chief editor), 1999, Minerogenetic series map of mineral deposits of China, 1:500,000, Precambrian, Paleozoic, Mesozoic-Cenozoic sheets with Explanatory notes, Chinese Academy of Geological Sciences, Geological Publishing House, 127 p.

Daukeev, S.Zh., Abdulin, A.A., Bespaev, Kh.A., Votsalevskiy, E.S., Miroshnichenko, L.A., and Shcherba, G.A., 2000, Minerageny map of Kazakhstan, 1:2,500,000, Ministry of Natural Resources and Environmental Protection, Republic of Kazakhstan, Almaty. Russian and English.

Drew, L.J., 1993, Geological map of the Tamdy mountains, Uzbekistan. USGS Miscellaneous investigation series, Map I-2386.

Eckstrand, O.R., and Good, D.J., 2000, World distribution of nickel deposits: Geological Survey of Canada, Open File 3791, 1:35,000,000, accompanied by three diskettes; http://www.NRCan.gc.ca/gsc/gicd/pubs/circular/2000_04/ofiles_e.htm#3791

ESCAP, 1985, Malaysia, Atlas of Mineral Resources of the ESCAP Region, v. 1, United Nations, 16 p., 1:2,500,000 geology and mineral resources maps.

ESCAP, 1990, Vietnam, Atlas of Mineral Resources of the ESCAP Region, v. 6, United Nations, 124 p., 1:1.5,000,000 geology and mineral resources maps.

ESCAP, 1990, Lao People's Democratic Republic, Atlas of Mineral Resources of the ESCAP Region, v. 7, United Nations, 19 p., 1:1.5,000,000 geology and mineral resources maps.

ESCAP, 1993, Cambodia, Atlas of Mineral Resources of the ESCAP Region, v. 10, United Nations, 87 p., 1:1.5,000,000 geology and mineral resources maps.

ESCAP, 1995, Geology and mineral resources of Afghanistan, Atlas of mineral resources of the ESCAP region, v. 11, 85 p., 1:2,000,000 to 2,500,000 geology, tectonics, magmatic formations and mineral resources.

ESCAP, 1996, Geology and mineral resources of Myanmar, Atlas of Mineral Resources of the ESCAP Region, v. 12, United Nations, 193 p., 1:1.500,000 geology and mineral resources maps.

ESCAP, 1998, Geology and mineral resources of Kyrgyzstan, Atlas of Mineral Resources of the ESCAP Region, v. 13, United Nations, 153 p., 1:1,000,000 mineral resources map.

ESCAP, 1999, Geology and mineral resources of Mongolia, Atlas of Mineral Resources of the ESCAP Region, v. 14, United Nations, 192 p., 1:3,000,000 mineral resources map.

Geological Survey of India, 1998, Geological Map of India (7th Edition) 1:2,000,000. Geological Survey of India, Hyderabad.

Geological Survey of India, 1999, Tectonic Map of India and Adjoining Countries 1:7,500,000. Geological Survey of India, Hyderabad.

Guo Wenkui, (editor in chief), 1987, Metallogenic map of endogenic ore deposits of China, 1:4,000,000, with guide, Institute of Geology, Chinese Academy of Geological Sciences, Cartographic Publishing House, Beijing, 72 p. Chinese and English.

Ilyin K.B., Poluektov V.N., Terentiev V.M., Shcheglov A.D., 1991, Map of mineral resources of Russia and adjacent countries, 1:5,000,000. VSEGEI, St. Petersburg.

Kamitani, M., and others, 1999, Mineral-resources map of the Circum-Pacific region, northwest quadrant, U.S. Geological Survey, Circum-Pacific Map Series, CP-46, 1:10,000,000, accompanied by explanatory notes, 29 p.

Kirkham, R.V., and Dunne, K.P.E. (compilers), 2000, World distribution of porphyry, porphyry-associated skarn, and bulk-tonnage epithermal deposits and occurrences: Geological Survey of Canada, Open File 3792, 1:35,000,000, accompanied by one diskette; http://www.nrcan.gc.ca/gsc/gicd/pubs/circular/2000_02/ofiles_e.htm

Map of Mineral Resources of Syria, 1:1,000,000, 1964, Ministry of Industry, Department of Geological and Mineral Research of Syria, prepared by TECHNOEXPORT, USSR.

Metallogenic map of Europe and neighboring countries, 1:2,500,000, 1982, Sheet 9: Near East (Ankara) plus Mineral deposit list, edited by BRGM and UNESCO, Paris.

Metallogenic map of Europe and neighboring countries, 1:2,500,000, 1983, Sheet 8: South Europe and Mediterranean Sahara (Athens), plus Mineral deposit list, edited by BRGM and UNESCO, Paris.

Metallogenic map of Turkey, 1:2,500,000, 1970, Mineral Research and Exploration Institute of Turkey, Ankara, Turkey.

Mineral Distribution map of Iran, 1:2,500,000, 1976, Taghizadeh, N., Geological Survey of Iran, Tehran, Iran.

Ministry of Natural Resources of Russia, 1994, Geological map of the Norilsk region at a scale of 1:200,000.

Phan Cu Tien, editor in chief, 1991, Geology of Cambodia, Lao and Vietnam, Explanatory note to the geological map of Cambodia, Lao and Vietnam, 1:1,000,000, 2nd edition, Geological Survey of Vietnam Hanoi, 159 p.

Ren Jishun, chief compiler, 1999, Tectonic map of China and adjacent regions, 1:5,000,000, plus The tectonics of China from a global view, Geological Publishing House, Beijing, 32 p.

Seltmann, R., Shatov, V., and Yakubchuk, A., eds., 2001, Mineral deposits map of Central Asia, scale 1:1 500 000. International Association on the Genesis of Ore Deposits (IAGOD). Published by NHM London and VSEGEI St. Petersburg.

Song, S., ed., 1992, Mineral resources maps of China: Beijing, Geological Publishing House.

Tectonic Map of the Middle East, 1:5,000,000, 1977, Petroconsultants Ltd., Dublin, Ireland.

Tectonic Map of Syria, 1:1,000,000, 1964, Ministry of Industry, Department of Geological and Mineral Research of Syria, prepared by TECHNOEXPORT, USSR.

General references, and papers referred to in presentations:

Berkman, D.A., and Mackenzie, D.H., eds., 1998, Geology of Australian and Papua New Guinean Mineral Deposits, AUSIMM Monograph 22.

Bundtzen, T.K., Fonseca, A., and Mann, R., 1995, eds., Geology and mineral deposits of the Russian Far East: Alaska Mineral Association Special Volume No. I, 277 p.

Buryak, V.A. and Khmelevskaya, N.M., 1997, Sukhoi Log as one of the world's largest gold deposits, Dalnauka, Vladivostok, 140 p. In Russian.

Carlile, J.C. and Mitchell, A.H.G., 1994, Magmatic arcs and associated gold and copper mineralization in Indonesia, in van Leeuwen, T.M., Hedenquist, J.W., James, L.P. and Dow, J.A.S., eds., Mineral Deposits of Indonesia: Discoveries of the Past 25 Years, Journal of Geochemical Exploration, v. 50, p. 91-142.

Chattterjee, A.K., and Rao, K.S., 1995, Majhgawan diamondiferous pipe, Madhya Pradesh, India: A Review, Journal Geological Soc.iety of India, v. 45, p. 175 –189.

Dodin, D.A., Chernyshov, N.M. and Yatskevich, B.A., 2000, Platinum deposits of Russia, Nauka, St. Petersburg, 753 p. In Russian.

ESCAP, 1999, Integrated assessment and development of mineral resources in the Greater Mekong Subregion, Mineral Concentrations and Hydrocarbon Accumulations in the ESCAP Region, v. 11, United Nations, 397 p. Includes Cambodia, Laos, Myanmar, Thailand, Viet Nam, and Yunnan Province, China.

Gandhi. S.M., 2001, The geology and mineralisation of Rampura-Agucha Zinc-Lead deposit, India, *in* Deb, M. and Goodfellow, W.D., eds., IUGS Deposit Modelling Program Workshop Proceedings, Sediment Hosted Lead-Zinc sulphide Deposits in the Northwestern Indian Shield.

Geology and Mineral Resources of Vietnam, 1990, General Department of Mines and Geology, Hanoi, 2nd edition, v. 1.

Gerel, O, 1995, Mineral resources of the western part of the Mongol-Okhotsk foldbelt, Resource Geology Special Issue no. 18, p. 151-157.

Goldfarb, R.J., and Miller, L.D., 1997, eds., Mineral deposits of Alaska: Economic Geology Monograph 9, 482 p.

Goldfarb, R.J., Phillips, G.N., and Nokleberg, W.J., Tectonic setting of synorogenic gold deposits of the Pacific Rim: Ore Geology Reviews, v. 13, p. 185-218.

Gupta, S.N., Arora, Y.K., Mathur, R.K., Iqbaluddin, Prasad, B., Sahai, T.N., and Sharma, S.B., 1997, The Precambrian geology of the Aravalli Region, Southern Rajasthan and Northeastern Gujarat, Memoirs of the Geological Survey of India, v. 123.

Hall, R., 1996, Reconstructing Cenozoic SE Asia, *in* Hall, R. and Blundell, D., eds., Tectonic evolution of Southeast Asia: Geological Society Special Publication no. 106, p. 153-184.

Hamilton, W., 1979, Tectonics of the Indonesian region, U.S. Geological Survey, Professional Paper 1078, 345 p.

Hamilton, J.V. and Hodgson, C.J., 1986, Mineralisation and structure of the Kolar Gold Field, India, *in* MacDonald, A.J., ed., Proceedings of Gold '86 Symposium, p. 270-283.

Hedenquist J.W., White N.C. and Siddeley G., eds., 1990, Gold mineralization of the Circum Pacific: Geology, geochemistry, origin and exploration, Journal of Geochemical Exploration, v. 35, p. 1-447.

Heinhorst, J., Lehmann, B. and Seltmann, R., 1996, New geochemical data on granites of Central Kazakhstan, *in* Shatov, V., Seltmann, R., Kremenetsky, A., Lehmann, B., Popov, V., Ermolov, P., eds., Granite-related ore deposits of Central Kazakhstan and adjacent areas, IAGOD Monograph Series, Glagol Publishing House, St. Petersburg, p. 55-65.

Heinhorst, J., Lehmann, B., Ermolov, P., Serykh, V. and Zhurutin, S., 2000, Paleozoic crustal growth and metallogeny of Central Asia; evidence from magmatic-hydrothermal ore systems of Central Kazakhstan, *in* Jahn, Bor-ming, Griffin, W.L. and Windley, B. F., eds., Continental growth in the Phanerozoic; evidence from Central Asia, Tectonophysics, v. 328, p. 69-87.

Herrington, R.J. , Zaykov, V.V. and Maslennikov, V.V., 1999, Volcanic hosted massive sulphide deposits of the Southern Urals. Field Excursion Guidebook 5th Biennial SGA Meeting and 10th Quadrennial IAGOD Symposium, London, 55 p.

Hughes, F.E., ed, 1990, Geology of Australian and Papua New Guinean Mineral Deposits. Australian Institute of Mining and Metallurgy, Monograph 14.

Hutchison, C.S., 1989, Geological evolution of Southeast Asia: Oxford Monographs on Geology and Geophysics, v. 13, 368 p.

Ishihara, S., 1981, Granitoids and ore genesis in East Asia, *in* Ishihara, S., and Sasaki, A., eds., Metallogeny of Asia, Geological Survey of Japan Report no. 261, p. 21-25.

Ivanov, S.M. and Ansdell, K.M., 2000, Constraints on the fluid evolution at Kumtor gold deposit: Textural relationships and stable isotopes. Geological Society of America, Abstracts with Programs, v. 32, no. 7, p. A-425.

Jankovic, S., 1984, Strata-bound low temperature Pb-Zn-Ba±F deposits in carbonate rocks of western Asia: Geotectonic setting and main metallogenic features, *in* Wauschkuhn, A. et al., eds., Syngenesis and epigenesis in the formation of mineral deposits, Springer-Verlag, Berlin, p. 373-390.

Jankovic, S., and Petrascheck, W.E., 1987, Tectonics and metallogeny of the Alpine-Himalayan belt in the Mediterranean area and western Asia, Episodes, v. 10, p. 169-175.

Khain, V.E. 1994, Geology of Northern Eurasia (ex USSR), Second part of the geology of the USSR: Phanerozoic fold belts and young platforms, Gebrüder Borntraeger, Berlin, 404 p.

Konstantinov, M.M., Zinnatullin, M.Z., and Prus, Yu.V., Scientific Editors; Gorodinsky, M.E., Miller, L., and Strujkov, S.F., Leading Editors, 1999, Gold placer deposits in Northeast Russia (Predictive Exploration Models), Committee of the Natural Resources of Magadan Oblast, Ministry of the Natural Resources of the Russian Federation, Moscow, 138 p. In Russian and English.

Kovalenker, V.A., 1995, Mineralogical and geochemical regularities in the formation of epithermal gold and silver ores, D.Sc Thesis., Moscow, Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry (IGEM), Russian Academy of Sciences. In Russian.

Mezhelovsky, N.V., Morozov, A.F., Gusev, G.S., and Popov, V.S., eds., 2000, Geodynamics and metallogeny: Theory and implications for applied geology, MNR Russian Federation and GEOKART, Moscow, 560 p.

Mitchell, A.H.G. and Leach, T.M., 1991, Epithermal gold in the Philippines; Island arc metallogenesis, geothermal systems and geology, London, Academic Press, 457 p.

Mo, X., Lu, F., Sheng, S., Zhu, Q., Hou, Z., Yang, K., Deng, J., Liu, X. and He, C., 1993, Sanjiang Tethyan volcanism and related mineralization. Geological Publishing House, Beijing, 267 p. In Chinese with English abstract.

Molnar, P. and Tapponnier, P. 1975, Cenozoic tectonics of Asia: effects of a continental collision, Science, v. 189, p. 419-426.

Moores, E.M., and Fairbridge, R.W., eds., 1997, Encyclopedia of European and Asian Regional Geology, Chapman and Hall, New York.

Naito, K. and Remy, F., 2001, Mining sector reform and investment: Results of a global survey, Mining Journal Limited, London.

Naito, K., Remy, F., and Williams, J. P., 2001, A comparative review of legal and fiscal frameworks for exploration and mining: Best practices, Mining Journal Limited, London.

Nikolaeva, E.I., Kazhikhin, M.A., and Golovanov, I.M., 1991, Ore potential of porphyry copper ore-magmatic systems. Otechestvennaya Geologiya, no.1, p. 28-34. In Russian.

Nokleberg, W.J., Bundtzen, T.K., Dawson, K.M., Eremin, R.A., Goryachev, N.A., Koch, R.D., Ratkin, V.V., Rozenblum, I.S., Shpikerman, V.I., Frolov, Y.F., Gorodinsky, M.E., Melnikov, V.D., and others, 1996, Significant metalliferous and selected non-metalliferous deposits and districts in the Russian Far East, Alaska and Canadian Cordillera, USGS Open File report 96-513, 385 pages (also in CD ROM).

Nokleberg, W.J., West, T.D., Dawson, K.M., Shpikerman, V.I., Bundtzen, T.K., Parfenof, L., and others, 1998, Summary terrane, mineral deposit, and metallogenic belt maps of the Russian far East, Alaska, and Canadian Cordillera, USGS Open File Report 98-136, CD-ROM.

Parfenov, L.M. and Spektor V.B., eds., 1997, Geological monuments of the Sakha Republic (Yakutia), Studio Design INFOLIO, Novosibirsk, 80 p.

Perelló, P., Cox, D., Garamjav, D., Sanjdorj, S., Diakov, S., Schissel, D., Munkhabar T.-O. and Oyun G., 2001, Oyu Tolgoi, Mongolia: Siluro-Devonian porphyry Cu-Au-(Mo) and high sulfidation mineralization with a Cretaceous chalcocite blanket, Economic Geology, v. 96, p. 1407-1428.

Puchkov V.N., 1991, The Paleozoic of the Uralo-Mongolian fold system. Earth Sciences and Resources Institute, University of South Carolina, Columbia, Occasional Publication, New Series, 7, Part II.

Qiu, Y.M., Gao, S., McNaughton, N.J., Groves, D.I., and Ling, W.L., 2000, First evidence of >3.2 Ga continental crust in the Yangtze craton of south China and its implications for Archean crustal evolution and Phaneozoic tectonics, Geology, v. 29, p. 11-14.

Savchuk, Yu.S. and Mukhin, P.A., 1993, Evolution of ore processes in the structure of Southern Tien Shan accretionary prism (Kyzylkum geodynamic polygon), Geotectonics 27, p. 63-81. In Russian.

Scotese, C.R., Nokleberg, W.J., Monger, J.H., Norton, I.O., Parfenof, L.M., Bundtzen, T.K., Dawson, K.M., and others, 2001, Dynamic computer model for the metallogenisis and tectonics of the Circum-North pacific, USGS Open File report 01-261, CD-ROM.

Seltmann, R., and Jenchuraeva, R., eds., 2001, Paleozoic geodynamics and gold deposits in the Kyrgyz Tien Shan. Excursion Guidebook of the IGCP-373 International Field Conference in Bishkek and the Kyrgyz Tien Shan, Kyrgyz Republic, 16-25 August 2001. IAGOD Guidebook Series 9, Natural History Museum, London, 183 p.

Seltmann, R., Shatov, V.V., Cole, A., Yakubchuk, A.S. and Jenchuraeva, R.J., eds., 2001, Paleozoic geodynamics and gold deposits in the Altaids sector of Kyrgyzstan – Introduction, *in* Paleozoic Geodynamics and Gold Deposits in the Kyrgyz Tien Shan, IAGOD Guidebook Series v. 9, Natural History Museum, London, p. 1–6.

Sengör, A.M.C., Natal'in, B.A. and Burtman, V.S., 1993, Evolution Of The Altaid Tectonic Collage And Palaeozoic Crustal Growth In Eurasia. Nature, v. 364, p. 299-307.

Sengör, A.M.C. and Natal'in, B.A., 1996, Palaeotectonics of Asia: fragments and synthesis, *in* Yin, A and Harrison, M., eds., The tectonic evolution of Asia. Cambridge University Press: 486-640.

Sengör, A.M.C., and Natal'in, B.A., 1996, Turkic-type orogeny and its role in the making of the continental crust, Annual Review of Earth and Planetary Sciences, v. 24, p. 263-337.

Shatov, V, Seltmann, R, Kremenetsky, A, Lehmann, B, Popov, V and Ermolov, P, 1996, Granite-related ore deposits of central Kazakhstan and adjacent areas, Glagol Publishing House, St. Petersberg, 396 p.

Shayakubov, T., Islamov, F., Krementsky, A., and Seltmann, R., eds., 1999, Au, Ag, and Cu deposits of Uzbekistan. Excursion guidebook to the International Field Conference of IGCP-373, Excursion B6 of the Joint SGA-IAGOD symposium, London/Tashkent, 27/28 August – 4 September 1999, 112 p.

Sillitoe, R.H., 1995, Exploration and discovery of base- and precious-metal deposits in the circum-Pacific region during the last 25 years, Metal Mining Agency of Japan, Tokyo, 127 p. Republished as Society of Resource Geology, Special Issue 19.

Subrahmanyam, V., Sarma, B.S., and Rao, M.S., 1991, Geochemistry, ore petrology and genesis of gold mineralisation Kolar Greenstone Belt, Karnataka, Geological Survey of India, Bulletin Series A, No. 52.

Torsvik, T.H. et al., 1992, Baltic: a synopsis of Vendian-Permian paleomagnetic data and their paleotectonic implications, Earth Science Reviews, v. 33, p. 133-52.

Trumbull, R.B., Morteani, G. Li, Z.L. and Bai, H.S. 1992, Gold metallogeny in the Sino-Korean platform, Springer-Verlag, Berlin. 202 p.

van Leeuwen Th.M., Hedenquist J.W., L.P. James and Dow J.A.S., eds., 1994, Mineral deposits of Indonesia: Discoveries of the past 25 years, Journal of Geochemical Exploration, Special Issue, v. 50, p. 1-500.

Veevers, J.J., 2001. Atlas of the billion-year earth history of Australia and its neighbours in Gondwanaland, GEMOC Press, Sydney, 76 p.

Wang, H., and Mo, X., 1995, An outline of the tectonic evolution of China, Episodes, v. 18, p. 6-16.

Wilde, A.R., Layer, A.R., Mernagh, T., and Foster, J., 2001, The giant Muruntau gold deposit: geologic, geochronologic and fluid inclusion constraints on ore genesis, Economic Geology, 96, p. 633-644.

White, N.C., Hedenquist, J.W., and Kirkham, R.V., 2001, Asia: the waking giant. Mining Journal supplement, March 2001, 12 p.

Wu, C.Y., Bai, G. and Xu, L.M., 1993, Types and distribution of silver ore deposits in China, Mineralium Deposita, v. 28, p. 223-239.

Yakubchuk, A.S., 2000. Bodaibo mesothermal goldfields in Siberia and Carlin-type gold mineralization in South China: a similarity of regional structural pattern, *in* Geology and ore deposits 2000: The Great Basin and beyond, J.K. Cluer, J.G. Price, E.M. Struhsacker, R.F. Hardyman, and C.L. Morris, eds., Geological Society of Nevada Symposium Proceedings, May 15-18, 2000, p. 539-547.

Yakubchuk, A.S., Cole, A., Seltmann, R. and Shatov, V.V., 2002, Tectonic setting, characteristics and regional exploration criteria for gold mineralization in Central Eurasia: The southern Tien Shan province as a key example, SEG Special Publication 9, p. 177-201.

Yakubchuk, A.S., Seltmann, R., Shatov, V.V., and Cole A., 2001, The Altaids: tectonic evolution and metallogeny, SEG Newsletter, 46, p. 1, 7-14.

Yang, K., 1994, Volcanogenic massive sulfide deposits in China, International Geology Review, v. 36, p. 293-300.

Yang, K., 1996, Gold deposits in China: main types and potential, International Geology Review, v. 38, p. 1006-1019.

Yin, A., and Harrison, M., eds., 1996, The Tectonic Evolution of Asia, Cambridge University Press.

Zhang, Y., Luo, Y., and Yang, C., 1988, The Panxi Rift in China: Beijing, Geological Publishing House, 325 p.

Zhai, Y, and Deng, J., 1996, Outline of the mineral resources of China and their tectonic setting: Australian Journal of Earth Sciences, v. 43, p. 673-685.

Zhou, T., and Goldfarb, R.J., eds., 2002, Tectonics and metallogeny of gold deposits in China, Mineralium Deposita, v. 37, p. 247-418.

Zonenshain, L.P., Kuzmin, M.I. and Natapov, L.M., 1990, Geology of the USSR: A plate tectonic synthesis, American Geophysical Union, Geodynamics Series, v. 21, 242 p.