Introduction to Economic Geology
Introduction

The field of Economic Geology is a specialized aspect of geology, concerning the identification and provenance of natural mineral deposits which are of economic interest to society.

Where to find it? Look around you!!
Economic Geology is essentially a branch of applied geology.

The end products of manufacturing are the result of the acquisition of mineral resources from their point of deposition.

There are a number of depositional settings which cover almost every environmental setting across the entire Earth.

Determining the likelihood, quantity of resources available and mineralisation processes are the key aspects of economic geology. The economic value of these resources is strongly influenced/governed by demand from society.

**Survey Methods:**
- Geological mapping
- Structural features
- Gravity/resistivity survey
- Alteration mineralogy
- Mineralisation
- Geochemical analysis
- Drilling
Geological Mapping and Structures

Geological maps are the basis for all local and regional analysis.

Deciphering the history and emplacement of successive rock units allows us to establish the likelihood of finding exploitable resources.

Finding these resources and knowing how they formed can lead us to further if not bigger resources connected to them.
Geological Surveying (Field mapping of structures)
B4, M1, M2 Students, Dept. Earth Resources Engineering, Kyushu University
Structural Geology
Plays an important role in many aspects of economic geology:

- Zone of high fluid input
- Deep seated faults provide conduits for heat transfer
- Localize mineralisation to a traceable source

“The present is the key to the past”
- James Hutton
Fluids and the root of ore precipitation (metals):
Most important metals are termed precious as their crustal abundances are several orders of magnitude lower than that of the common rock forming elements. These are geochemically referred to as either the Chalcophile elements (Sulfide affinities) or Platinum Group elements (common in native form).
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The Mobile Crust – Always on the move!
**Fluids and the root of ore precipitation (metals):**
Although precious and semi-precious metals are not abundant in the crust, they are mobilised by fluids associated with magmatism and subsequent volcanism in the shallow crust.

These volcano-magmatic activities form conduits and zones of high heat flow, generating thermal convecting and advecting aqueous fluids which transport metals in dominantly bi-sulphide, bi-chloride or carbonate complexes.
Fluids and the root of ore precipitation (metals)

Corbett & Leach (1997)
Fluids and the root of ore precipitation
Kyushu Island and major epithermal deposits

Kyushu Epithermal overview

- Majority low-sulfidation epithermal
- Ranging from 5 to 0.8 Ma
- Related to calc-alkaline volcanism
  - Magnetite series magmatism
- Most economic deposits hosted in the southern province.

Nansatsu District

- Hosts classic high-sulfidation epithermal deposits.
- Single low-sulfidation deposit in the southwest, whilst the southeast has many low-sulfidation deposits in the Quaternary volcanic rocks.
Characteristics of depositional area

Southwest Nansatsu District
Nansatsu-type Characteristics

- Composed of residual silica bodies
  - Vuggy silica texture from leached host
- Shrouded in **advanced argillic alteration**
- Disseminated ore
- **High-sulfidation state** mineralogy
  - Enargite/luzonite, native Au, pyrite
- Typical temperature range 250-270°C
- **Supergene remobilisation**, enriching Au ore
  - Goethite, scordorite and jarosite products
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Kasuga high-sulfidation deposit high-grade ore

Native Au
Tunneling systems in the Kago mining area.
Ore and gangue petrography

- Host rock breccia
- Crustiform and colloform bands
  - Colloform adularia band
  - Microcrystalline quartz and crustiform repeating bands
- Microcrystalline quartz and crustiform bands
  - Pyrite and polysial, chalcopyrite, electrum

Massive quartz

Brecciated silicified Shimanto Supergroup

2 cm
Analytical techniques

Ore and gangue petrography

Common ore minerals: *Pyrite, polybasite (pol), chalcopyrite (cpy), covellite (cv), electrum (el)*. Covellite is secondary product, from the breakdown of chalcopyrite.

**Electrum Characteristics**

| High-grade ores: | Anhedral course-grained (≤200\(\mu\)m), hosted in quartz breccias and outside colloform bands. |
| Low-grade ores:  | Fine-grained (≤50\(\mu\)m), hosted between microcrystalline and crustiform banded quartz. |
Analytical techniques

Ore and gangue petrography

Quartz Textures
Colloform, moss, flamboyant, microcrystalline, chalcedonic

Adularia Textures
Colloform and crustiform are common in banded ore veins. Cockade growth is present on brecciated ore veins.
Analytical techniques
Fluid inclusion microthermometry

Introduction
A technique used to determine the temperature and salinity of the fluids that carried the metals to their point of deposition. This can give us insights into the thermal regime with which precipitation took place. This can assist us in terms of stable isotope mass spectrometry.
Analytical techniques
Stable isotopic measurement

Quartz $\delta^{18}O$

Ore bearing quartz: Precipitation temp. 220-240°C
Suggesting $\delta^{18}O$ range of $-6.5$ to $-0.3$‰
based on Clayton et al. (1972).

Chalcedonic quartz: Precipitated at low temp.
85-180°C, based on Kita et al. (1985) fractionation equations for a composition analogous to ore bearing quartz veins.
**High-sulfidation Nansatsu-type**

- **Au-Cu type**
  - Temperature Range: 240-300°C
  - Host: Nansatsu Group
  - Alteration type: Adv. Argilllic
  - Mineralogy: Enargite/luzonite, Au

**Fluid Characteristics:**
- Mixed
- Hypogene to late-stage supergene

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**Low-sulfidation (adularia-quartz)**

- **Au-Ag type**
  - Temperature Range (mode): 220-240°C
  - Host: Shimanto Supergroup
  - Alteration type: Illite, Smectite
  - Mineralogy: Pol, ccp, cv, py, el

**Fluid characteristics:**
- Meteoric dominant
- Water-rock interaction, recirculated
Kago deposit shows a similar Au composition to surrounding regional low-sulfidation deposits.
Fluids and the root of ore precipitation (metals)

KYUSHU UNIVERSITY
Department of Earth Resources Engineering

Economic Geology Laboratory

PACIFIC RIM GOLD-COPPER MINERALIZATION MODELS

HIGH SULFIDATION

LOW SULFIDATION

Porphyry

Cu Au Mo

Adularia-sericite
epithermal Au-Ag

Quartz-sulfide
Au + Cu

Carbonate-base metal

Quarrying ring

Structural control

Lithological control

Breccia pipe

Sediment replacement hosted Au

Approx. vertical scale

Reference

Fluid flow

Mineralization
Copper is a semi-precious metal, essential for telecommunications and microprocessors.

The development of infrastructure in a growing economy relies heavily on resources from very large deposits (the porphyry Cu-Au, Cu-Mo deposits) of the Circum-Pacific region.

Southern parts of Peru and Chile are the biggest producers of copper ore concentrates on the planet.

Owing to their abundance of porphyry mineralisations along the volcanic front of the East Pacific.

*Batu Hijau Porphyry Cu-Au (Indonesia)*
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Sustainable energy solutions require greater consumption of rare earth elements (REE).

REE Elements
Nd – Neodymium
Dy – Dysprosium
Y – Yttrium (semi)
Metals for life

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Rare Earth Elements are by their very nature difficult to obtain.

Although more abundant than the precious metals the greatest difficulty relates to their difficulty in excavation.

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Scarcity of resources means we have to look to more exotic locations for resources.

Black smokers are vents situated several km below the surface. Typically situated over spreading ridges or subduction trenches, these contain abundant heavy metals in the chimney structures.
Frontiers in geology – Black Smokers