

**Framboidal copper sulphides associated with bitumen:
implications to the genesis of the El Soldado copper deposit, Chile**

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Bitumen (solid petroleum) has been recognized in the ores from the Cretaceous El Soldado copper deposit, central Chile. In association with this bitumen, copper ores contain abundant sulphide framboidal and spheroidal aggregates made of bornite-chalcocite-chalcopyrite, as well as the common pyrite. Paragenetic relationships suggest at least two generations of primary spheroidal sulphide aggregates, one pre-ore and another related to copper mineralization, which also occurred with the pseudomorphic replacement of pre-ore spheroids. Successive stages of development of these spheroidal aggregates lead to the formation of massive copper-sulphide ore.

Textural evidence suggests three separate stages of sulphide formation: (1) initial disseminated pyrite and arsenopyrite was formed at the time of deposition of the host volcanic sequence; (2) burial of the volcanic sequence was associ-

ated with the formation of early (north-south) faults followed by oil migration into the fault zones and permeable horizons: this second stage was associated with biological and thermal degradation of petroleum and the formation of framboidal pyrite, sphalerite and chalcopyrite; and (3) early (north-south) fault reactivation and development of new (northeast-southwest) faults provided a focus for copper mineralization; bitumen was solid when copper mineralization occurred, and was veined and replaced by copper sulphides.

Copper mineralization occurred after destruction (biological-thermal) of a pre-existing petroleum reservoir. It is suggested that the stage of sulphide formation associated with the petroleum (now preserved as bitumen) provided a reductant and a source of S which controlled the later episode of copper mineralization.