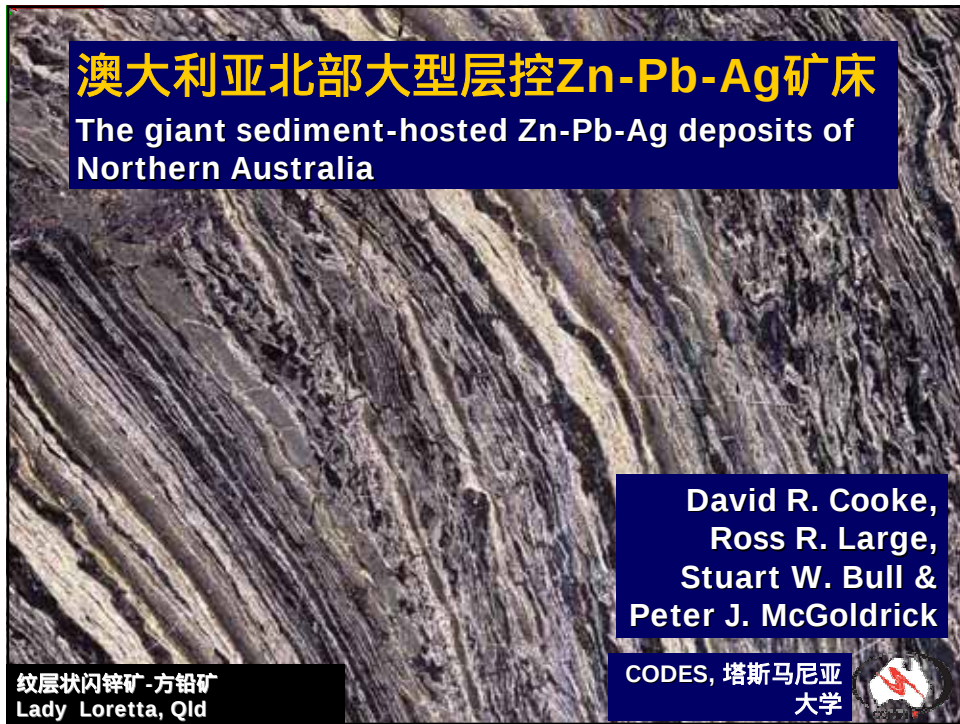


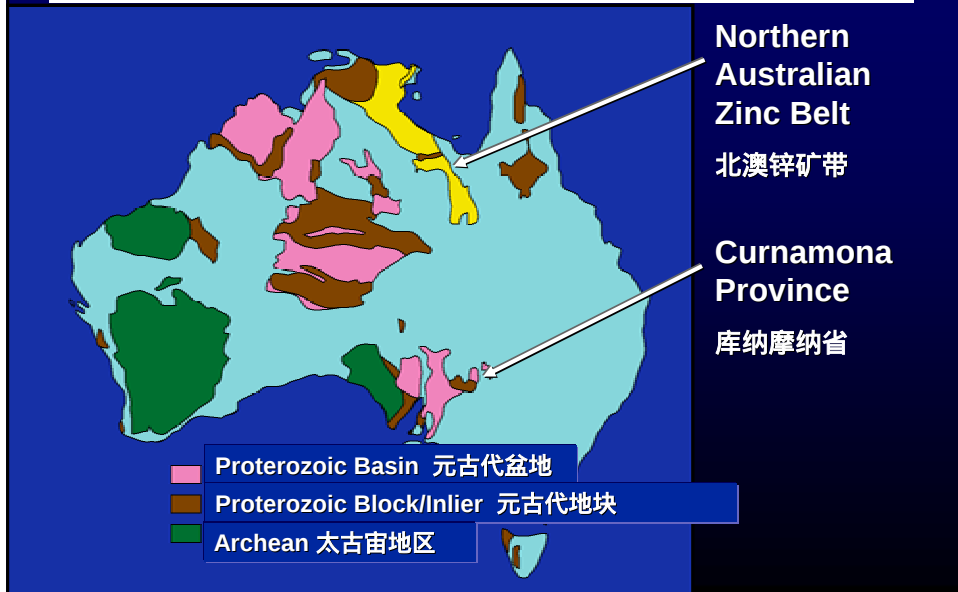


讲座提纲 Overview		
	• Overview of Australian stratiform sediment-hosted Zn-Pb-Ag deposits	
	澳大利亚层控 Zn-Pb-Ag 矿床概况	
	• Review of genetic models 成因模式回顾	
	• Exploration Implications 勘查预测	
Laminated ore, HYC, NT 纹层状矿石, HYC, NT		Folded sphalerite-galena ore, Lady Loretta, Qld 褶皱状闪锌矿 - 方铅矿, Lady Loretta, Qld



Australian Proterozoic Terranes

澳大利亚元古代岩体



Proterozoic Zn Belt

元古代锌矿带

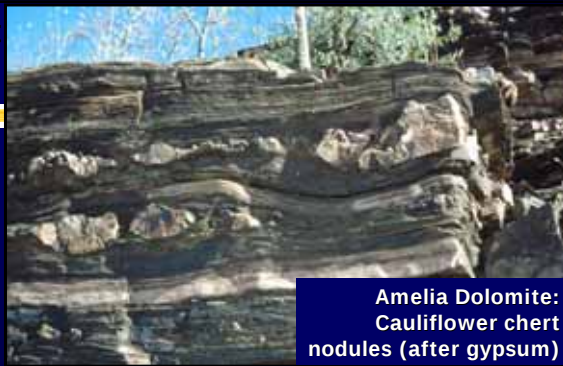
- Current exposed extent ~1200 km across central northern Australia
目前出露范围为横穿中北澳~1200 km
- Multi-phase basin system developed within an intra-epi-continental rift setting
在陆内陆源裂谷环境内发展而成的多相盆地系统





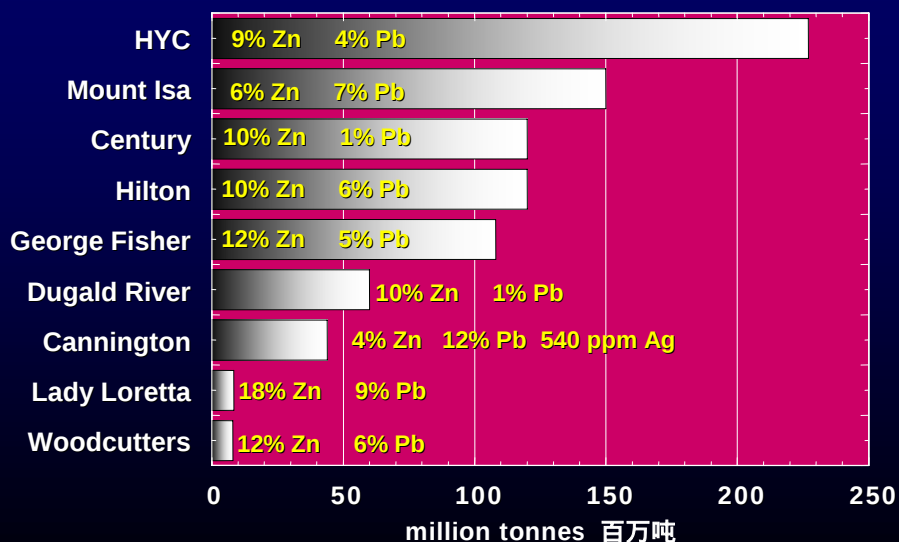
Proterozoic Zn Belt 元古代锌矿带

- Terminated by 1590-1500 Ma Isan Orogeny
15-15.9亿年前的
Isan造山运动
- Murphy Inlier subdivides the belt into two major depositional elements with different metamorphic histories
墨菲地带可以进一步
分成两个矿带，两者
具有不同变质历史



Australian Zinc Belt — Resources

澳大利亚锌矿带 - 资源





History of genetic models

成因模式的研究历史



Key papers

重要文献

Knight (1957)

Stanton (1962)

Croxford & Jephcott (1972)

Lambert (1976)

Williams (1978, 1979)

Neudart & Russell (1981)

Eldridge et al. (1991)

Perkins (1984, 1997)

Large et al. (1998)

Broadbent et al. (1998)



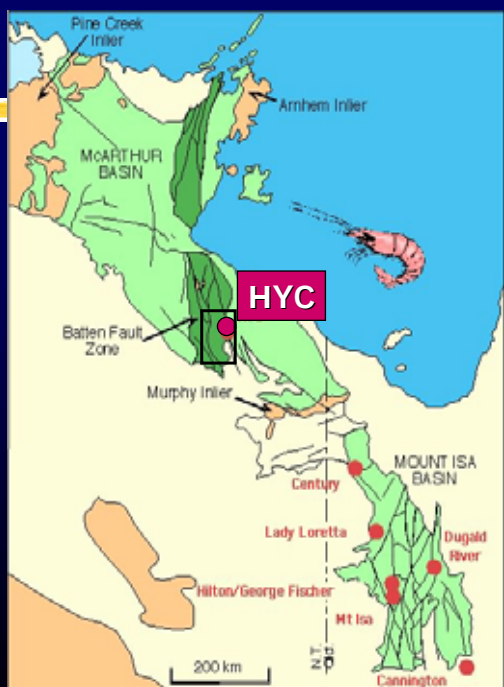
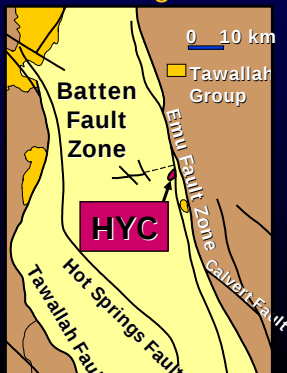
McArthur 盆地

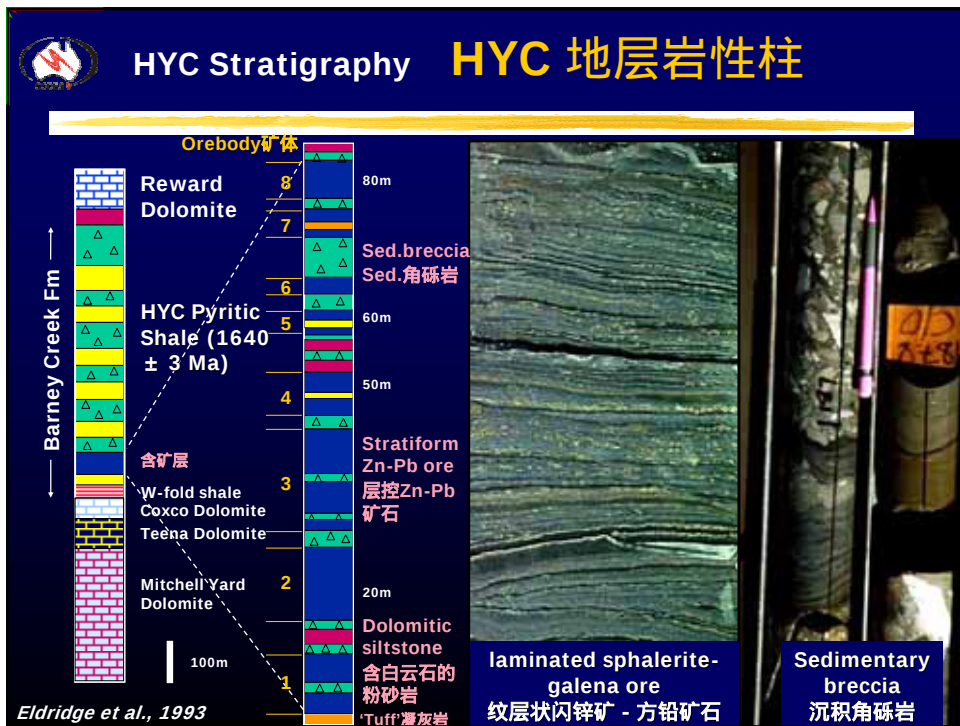
- Unmetamorphosed clastic rift & carbonate sag fill sequences

未变质的碎屑裂谷和碳酸盐坳陷充填层序

- One major stratiform Zn-Pb-Ag deposit: HYC

一个主要的Zn-Pb-Ag层控矿床
: HYC







HYC (McArthur 河)

- Hemimorphite -bearing gossan & outcropping base metal sulfides discovered by CEC in 1955
1955年由CEC发现的含异极矿的铁帽和出露的贱金属硫化物



HYC:露头的发现



HYC (McArthur 河)

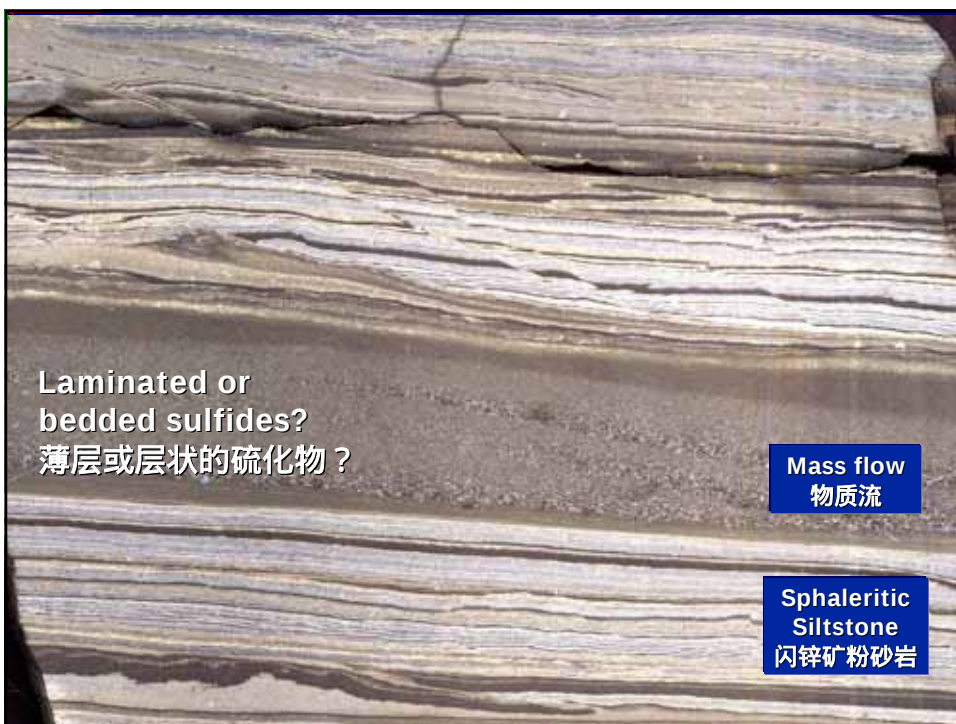
- Resource: 227 Mt @ 9.2% Zn, 4.1% Pb
资源：227 Mt @ 9.2% Zn, 4.1% Pb
- Current mine: 125 Mt @ 13% Zn, 6% Pb, 60 g/t Ag
当前矿山：125 Mt @ 13% Zn, 6% Pb, 60 g/t Ag



Underground Photo Courtesy of
McArthur River Mine
McArthur河矿照片



HYC -high-grade ore **HYC-高品位矿石**





Clastic Sulfides? 碎屑状硫化物？

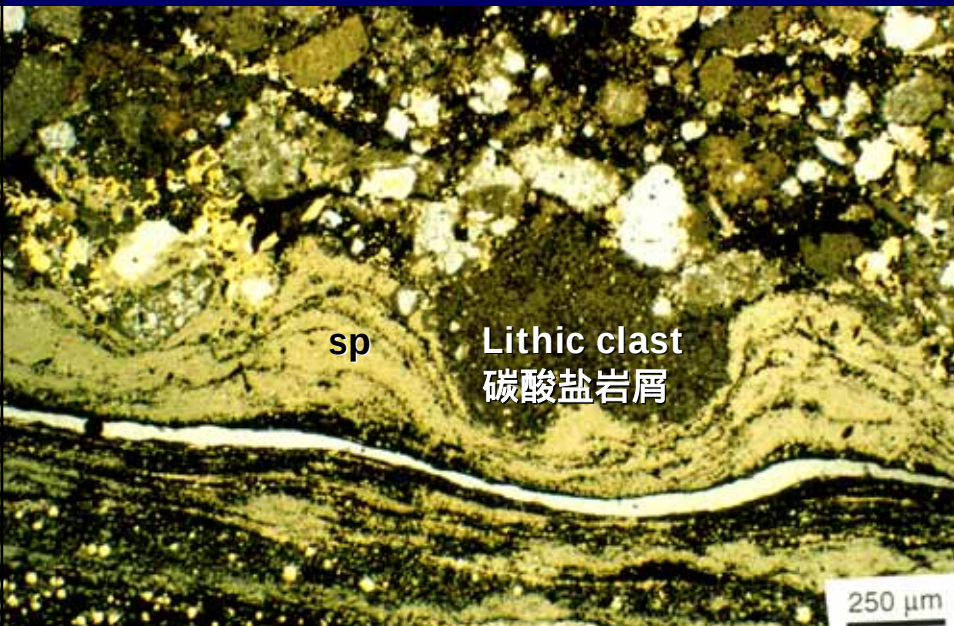
Turbidite with
sulfide clasts
带有硫化物碎屑的
浊积岩



Laminated sphaleritic siltstones
纹层状的闪锌矿粉砂岩



Base of turbidite 浊积岩底部



sp

Lithic clast
碳酸盐岩屑

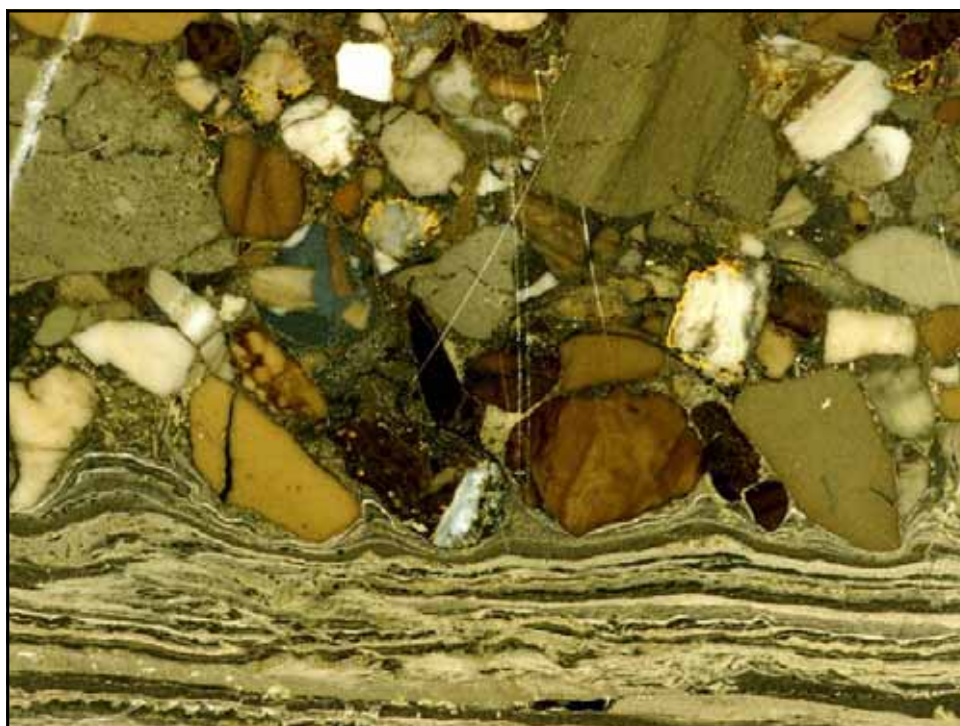
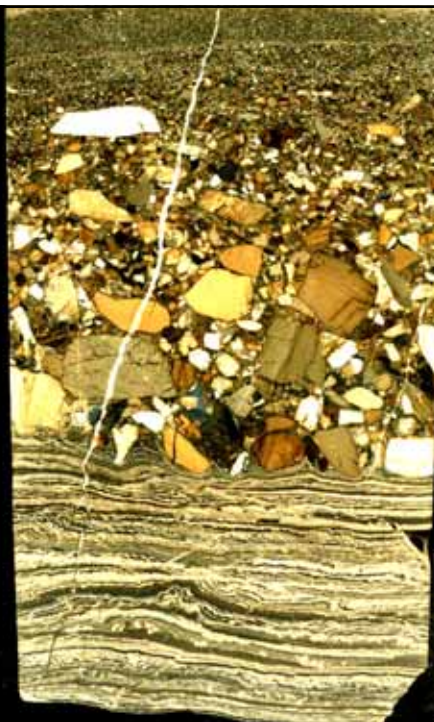
250 μm



沉积角砾岩与矿石 的关系

Sedimentary
Breccia
沉积角砾岩

Laminated
Zn-Pb ore
纹层状Zn-Pb矿

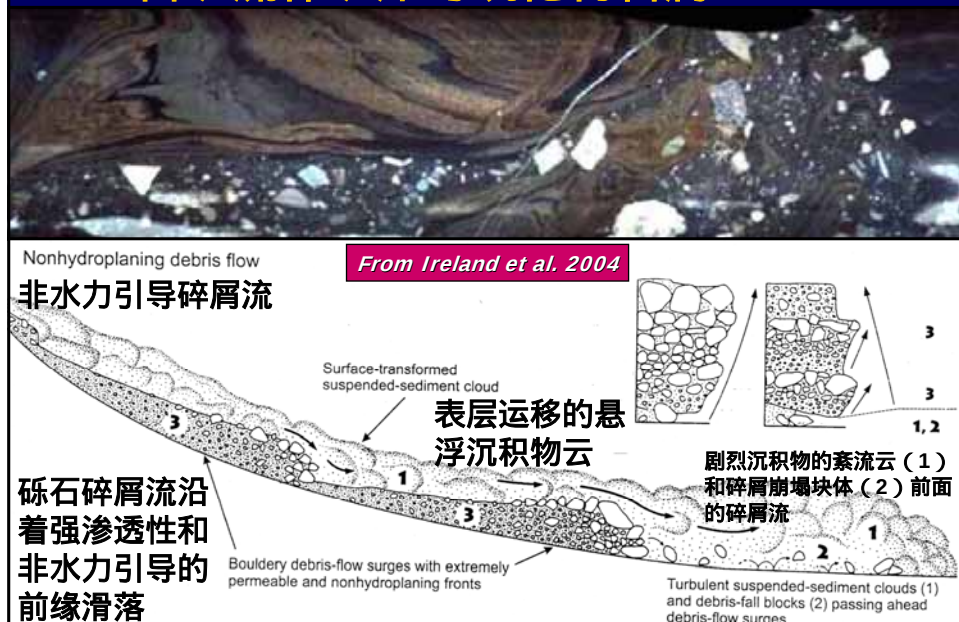




Breccia - Ore Relationships 角砾岩与矿石的关系



Mass flow deposits & sulfidic clasts 含矿流体矿床与硫化物岩屑





Tectonic controls on sedimentation

构造运动对沉积作用的控制

Deep seismic events in basin

盆地中的深源地震事件

- movement on N- ± E-trending faults

N- ± E方向断裂运动

- sediment breccia deposition off faults

远离断层的沉积角砾岩矿床

- Pb-Zn brine release along faults

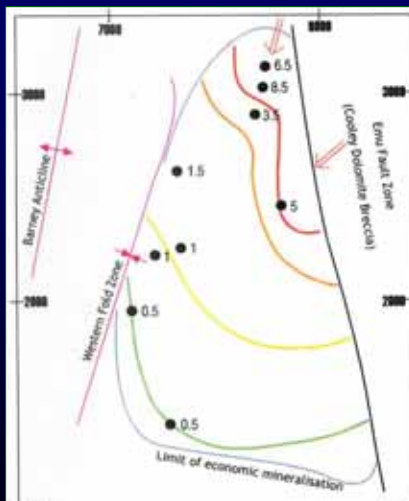
Pb-Zn卤水沿断层释放

- dense brine pulse forms bottom-hugging current

高盐度（高浓度）的卤水脉动形成了底部粘滞的流体

- Pb-Zn deposition in muds from brine current

Pb-Zn沉淀富集在卤水流体携带来的粘土中



Isopach map of I1/2 interore breccia thickness, Ireland et al. 2004 ; I1/2 矿体内角砾岩厚度等值线图



HYC: Sedimentary-Exhalative Model

HYC: 沉积喷发模型

Seawater (SO_4^{2-} -bearing)

海水 (含 SO_4^{2-})

brine pool (free H_2S)

卤水区 (释放 H_2S)

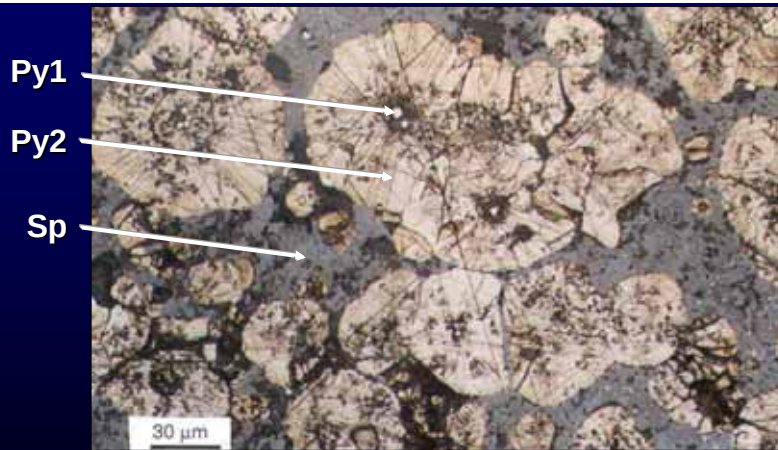
Zn-Pb- SO_4^{2-} -bearing brine

含Zn-Pb- SO_4^{2-} 的卤水



HYC: Sulfide Microtextures

HYC: 硫化物显微结构

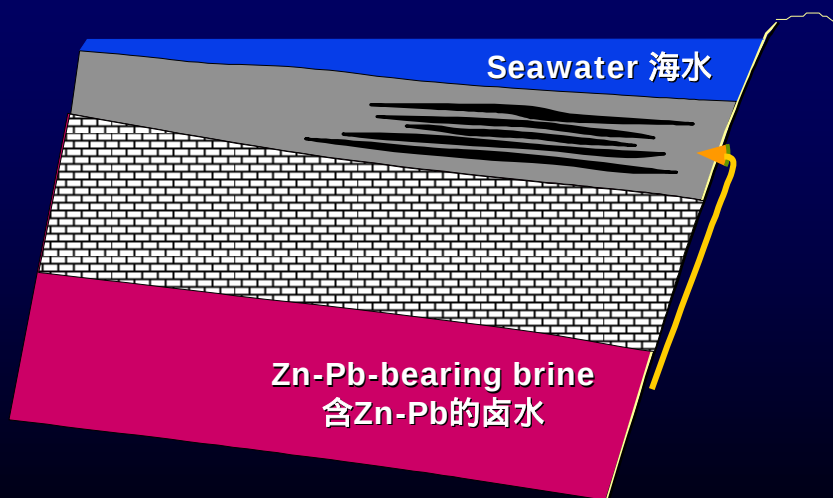


- Py1: micron sized crystals that are probably syn-sedimentary
- Py2: coarse grained overgrowths of diagenetic origin
- Py1: 可能为同时期沉积的微米尺寸的晶体
- Py2: 纹理粗糙生长过度的成岩起源

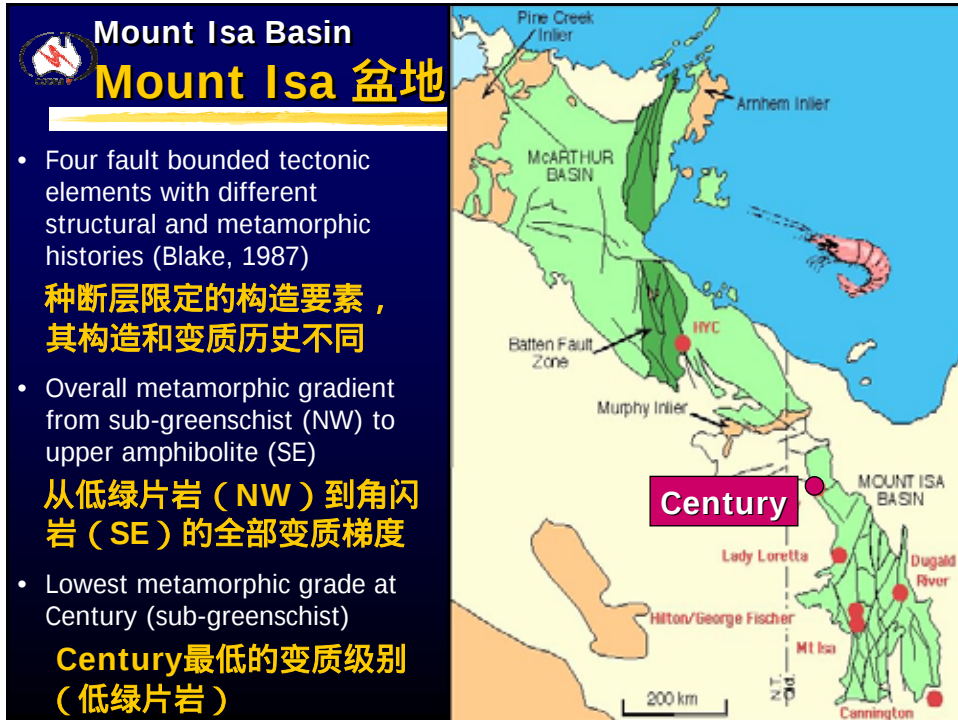


HYC: Early Diagenetic Replacement model

HYC: 早期的成岩交代



Hinman (1998)





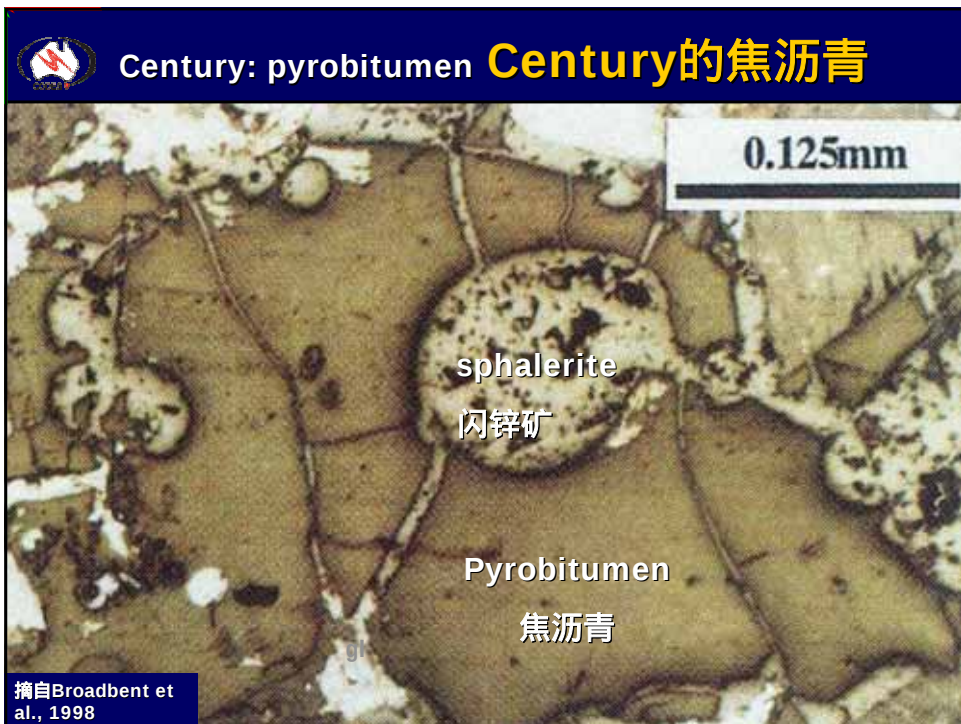
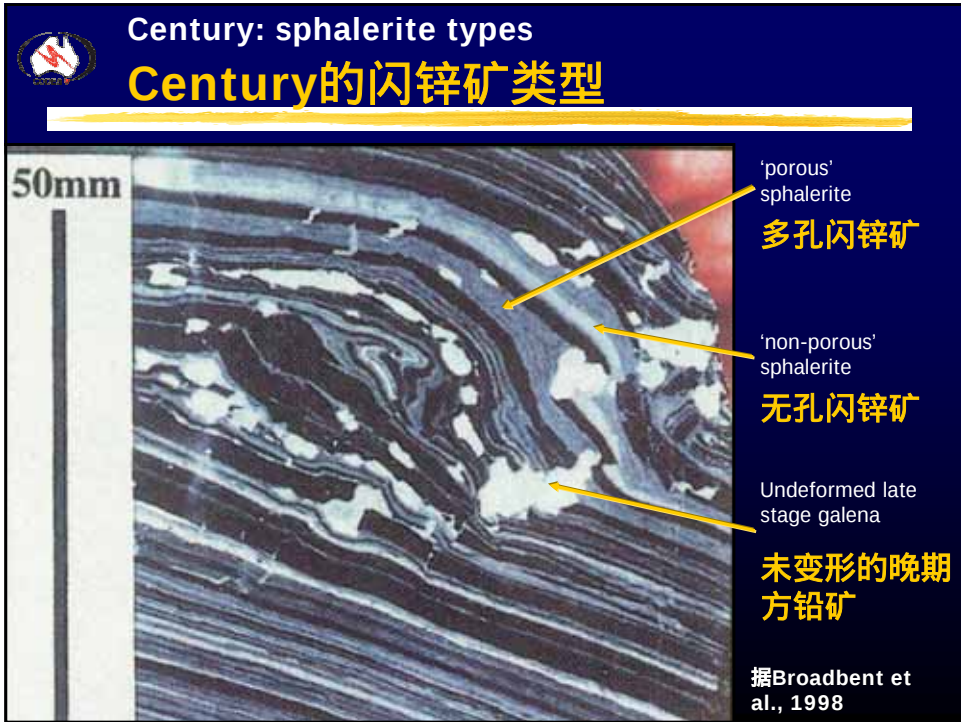
Century Zn Deposit

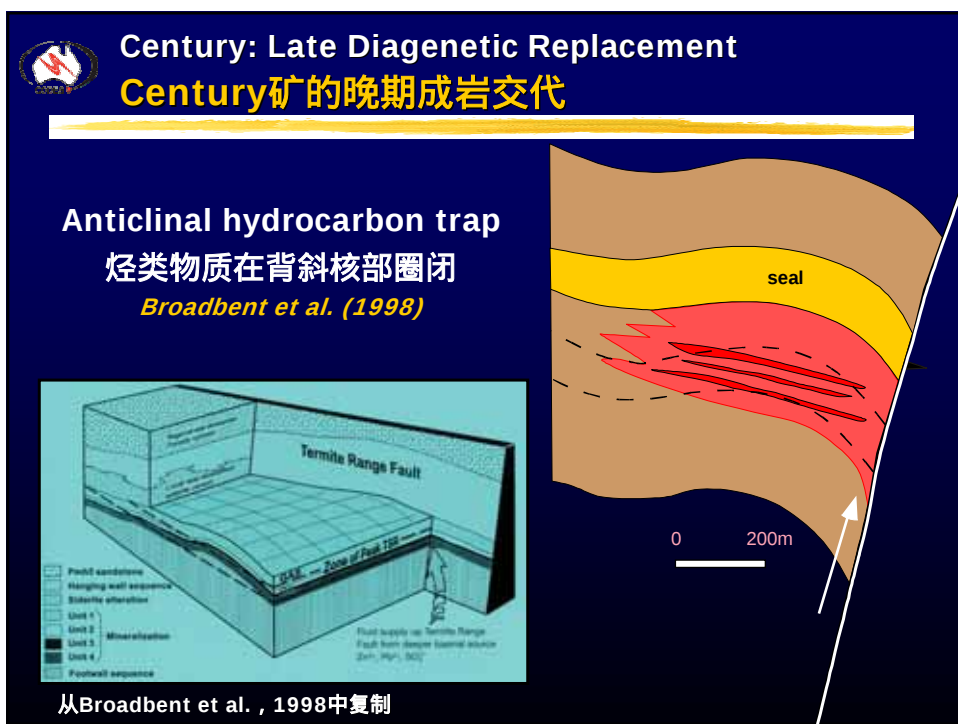
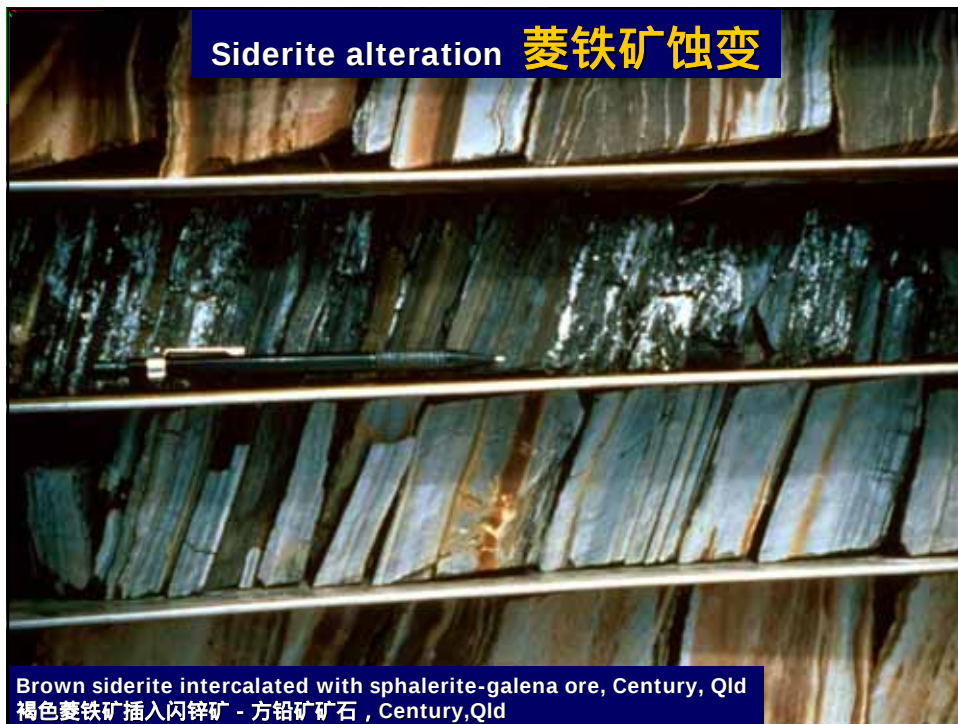
Century Zn矿床

- Hosted in 1595 Ma Lawn Hill Formation black shales and siliciclastics -contrasts with dolomitic shales at the other major zinc belt deposits

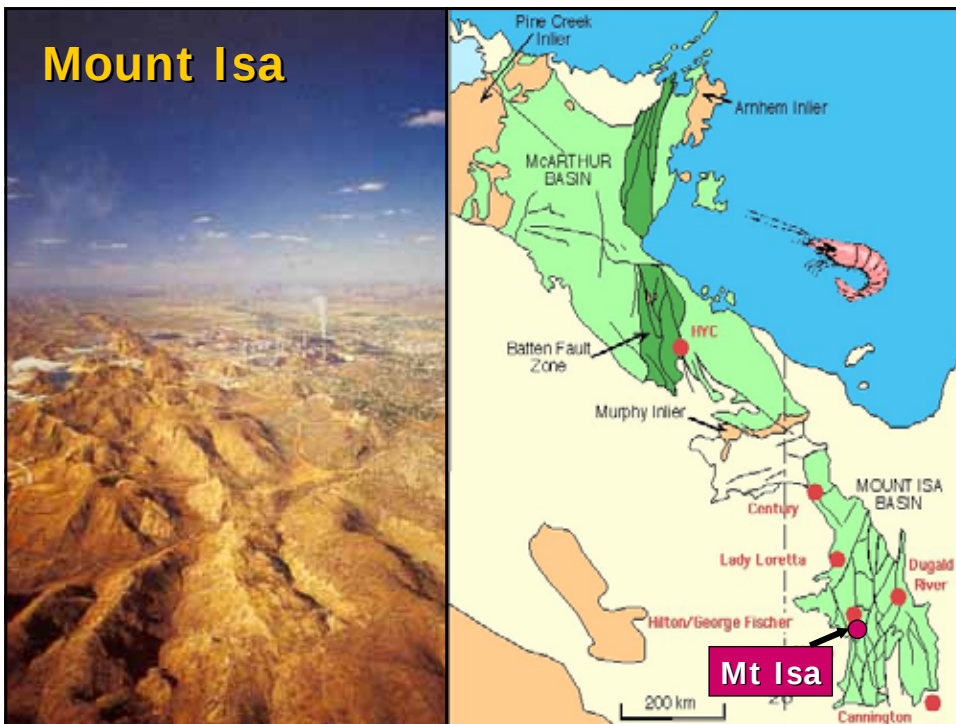
发育于1595的Ma Lawn Hill组黑色页岩、硅质碎屑中，与其它主要锌矿带的白云质页岩不同







Mount Isa



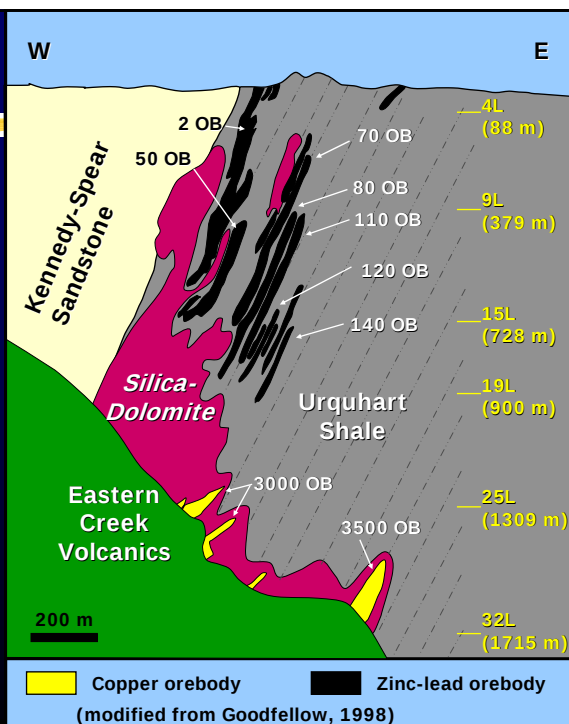
Mt Isa





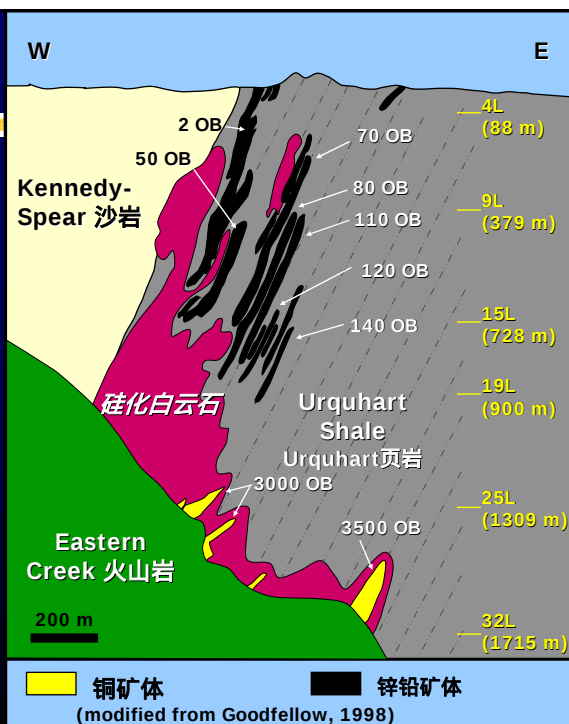
Geology 地质特征

- About 30 stratiform, sheet-like orebodies hosted by Urquhart Shale
- 大约为30个层状片状矿体，围岩为Urquhart页岩
- Tuffaceous marker beds: SHRIMP zircon age of 1653 ± 7 Ma
- 凝灰岩标志层：
SHRIMP锆石年龄为
 1653 ± 7 Ma



Geology 地质特征

- Three major deformation events (Isan Orogeny)
- 三次主要变形 (Isan Orogeny)
- Mine sequence is in a steeply west dipping limb of a regional D_2 anticline
- 矿带分布于区域内 D_2 背斜向西陡倾斜的一翼上
- Lower greenschist metamorphic grade
- 较低的绿片岩变质级别

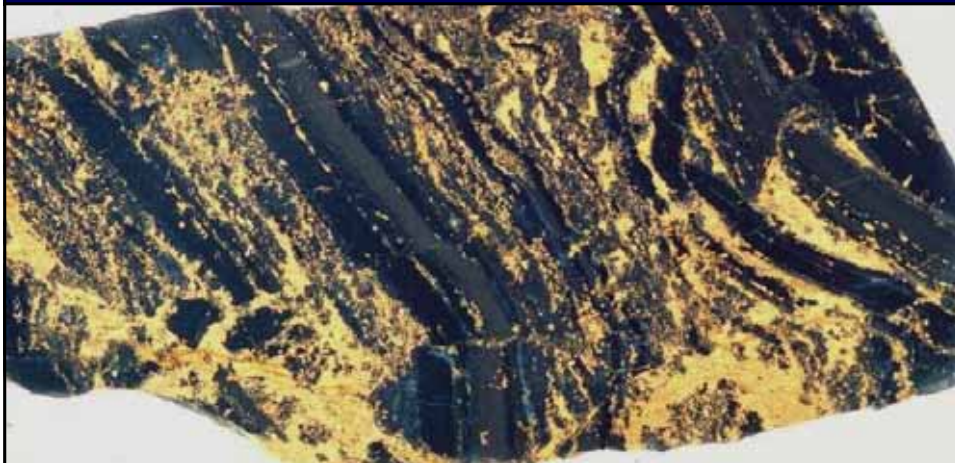






Mt Isa Copper Ore **Mt Isa 铜矿石**

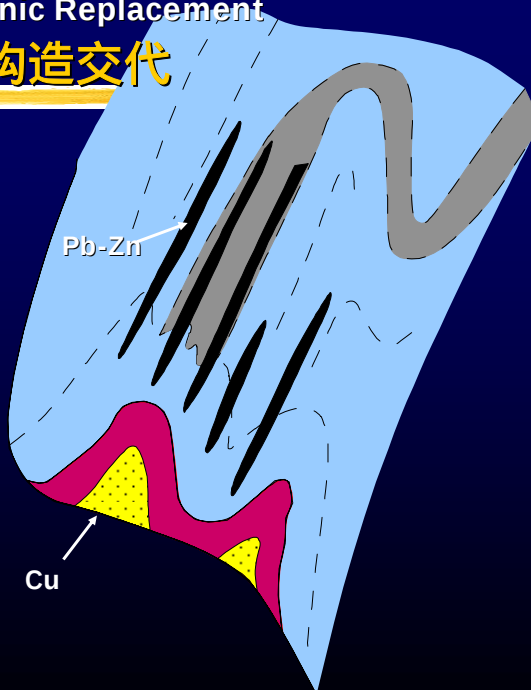
- Cu introduced at the end of a structural event that deformed the Pb-Zn ores, but did not deform the Cu ores (Perkins, 1984)
- 在一次构造事件之后Cu加入，该事件使Pb-Zn矿石发生变形，Cu矿体却未变形。



Mt Isa: Syn-Tectonic Replacement

Mt Isa: 同期构造交代

Perkins (1997)





Conclusions 结论

- Zinc belt ores hosted by laminated dolomitic, carbonaceous, pyritic siltstones - syngenetic, diagenetic, epigenetic?

锌成矿带的围岩是纹层状白云岩，碳酸岩，硫化铁粉砂岩 - 同生，次生？

- Increasing degrees of deformation and metamorphism coincide with more abundant discordant ore textures

逐渐增加的矿体结构不整合是变形和变质作用程度加深的表现

- The host rocks are anomalously reducing compared to the underlying basin fill

相比于下伏盆地的充填层序，围岩呈异常的还原状态。

- Mineralising brines: oxidising, low temperature and saline

成矿卤水是氧化的、低温的、高盐度的



含微生物的纹层状“带绒毛的”黄铁矿，Lady Loretta, Qld



Exploration Implications

- **Reduced sulfur at the trap site is the key to ore deposition**

- **Exhalative trap:**

- deeper-water sub-basins with high surface productivity (reducing conditions, abundant organic C)

➤ *H₂S production at trap site*

- **Diagenetic trap:**

- addition of H₂S via fluid mixing?
- interaction with earlier-formed pyrite?
- interaction with H₂S gas and/or hydrocarbons

➤ *petroleum reservoir model?*



HYC Ore