High grade Mn ore: Can it influence the cost of future EMM production in China?

高品位锰矿是否会影响中国未来的EMM生产成本

Presented by

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Presentation Layout

- Context 背景一两国的锰矿状况
- Factors to consider in the use of high grade Mn ore in the EMM industry 在EMM产业使用高品位矿石所需要考虑的因素
  - Ore price, availability and grade
    矿石价格，矿石的供应和品位
  - Process changes
    生产过程的变化
  - Material/waste disposal practices
    废渣的处置方法
- Scenario planning and comparison
  使用两种矿石生产成本的比较分析
- Take home points 问题供大家思考

1. 对比中国南非高低品位矿石的情况 Context

High grade Mn ore - RSA:

- 44% to 48% Mn content 锰含量
- At 85% recovery require 2.6 to 2.8 ton ore per ton EMM

  以85%的回收率，生产一吨电解锰需要2.6 – 2.8吨矿石
- Typically oxide mineralogy

  典型的氧化物矿物学
- Requires reduction before leaching 矿石浸出前需要还原
- Needs 0.2t acid per ton EMM

  生产每吨EMM需要用酸0.2吨

Low grade Mn ore - China:

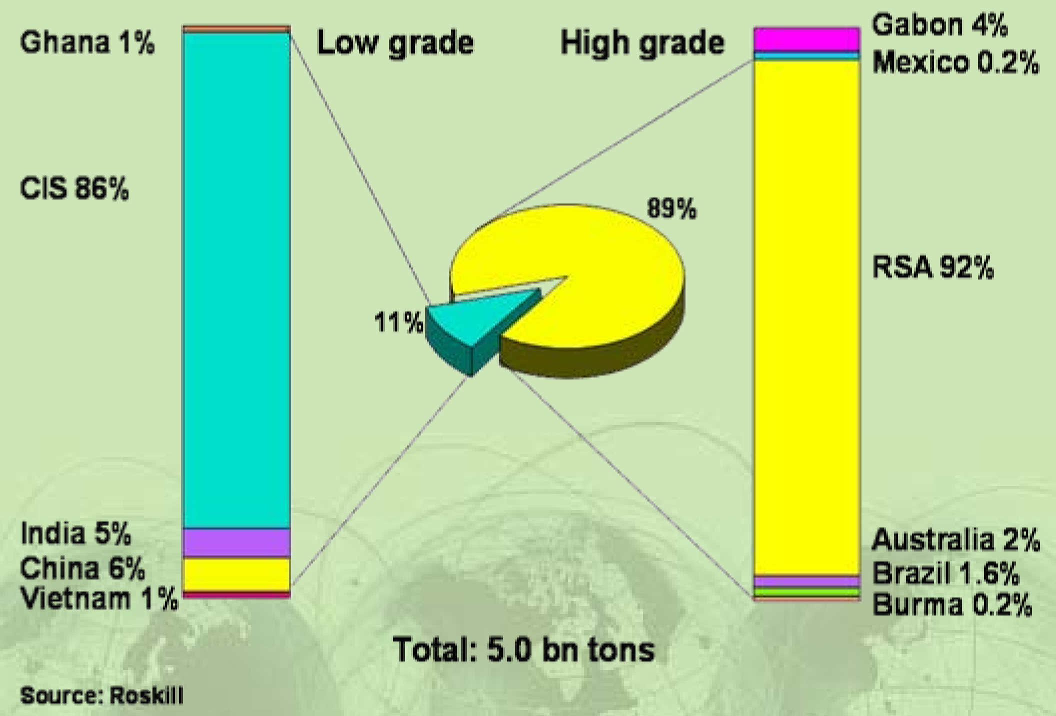
- 14% to 18% Mn content
- At 75% recovery require 6.9 to 8.9 ton ore per ton EMM
- Typically carbonate mineralogy

  典型的碳酸盐矿物学
- Needs no reduction before leaching
- Needs 2.2t acid per ton EMM

World Mn Reserves

世界锰矿储量

(Roskill, The Economics of Manganese, 2000)



低品位锰矿石 – 独联体国家

高品位锰矿石 – 南非

2.Factors to Consider需要考虑的因素

- 2.1 Local ore availability, price and grade 本地矿石的供应、价格和品位
- 2.2 Process advantages and disadvantages

  生产工艺的利弊
- 2.3 Material and waste handling and disposal practices

  矿物废渣的处理和放置方法

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2.1.1本地矿石供应Ore Availability

- Although South Africa has the majority of high grade Mn ore reserves, Australia is currently the largest producer of high grade Mn ore 虽然南非有着世界上最多的高品位锰矿储量，澳大利亚目前仍然是世界上最大的高品位锰矿生产国
- China is the largest importer of seaborne high grade Mn ore in the world and imported 7.6Mt wet ore in 2008 for mostly the ferro-alloy industry, average grade 44% (China Customs, 2008)

  中国是世界上最大的船运高品位锰矿进口国，2008年共为其铁合金产业进口了760万吨湿矿，平均锰矿品位达44%（2008年中国海关数据）
- China local ore is predominantly low grade $MnCO_3$ ore. Produced 18.8Mt in 2008, average grade 20%, of which 67% was carbonate low grade ore and 33% MnO_2 (IMnI Market Research)

  中国本地的锰矿石绝大部分是低品位的碳酸锰矿。2008年中国锰矿产量达1880万吨，矿石平均品位为20%。其中67%是碳酸盐低品位矿，剩下33%是二氧化锰（锰协市场研究）

2.1.1本地矿石供应Ore Availability

- Chinese EMM industry is the main consumer of domestic ore (balance used in ferro-alloy) and plants are typically situated close to Mn ore reserves (Mn Triangle)中国国内锰矿的主要消费市场是中国的电解锰产业（剩下的则用于铁合金生产）。因此有很多的EMM工厂就建立在离锰矿很近的地方 （中国西南部的锰金三角）
- Total China Mn ore reserve around 421Mt ore (CISRI)

  中国锰矿的总储量大约为4.21亿吨 (中国钢铁研究总院)
- Depending on production rate, local $MnCO_3$ ore reserves can deplete in specific areas in the next 10-15 years (Hunan, Shanxi and Chongqing traditional EMM production areas) – CISRI

  取决于生产速度，本地的碳酸盐锰矿储量可能在未来10-15年在一些地区枯竭（包括湖南、山西和重庆的传统EMM生产区）

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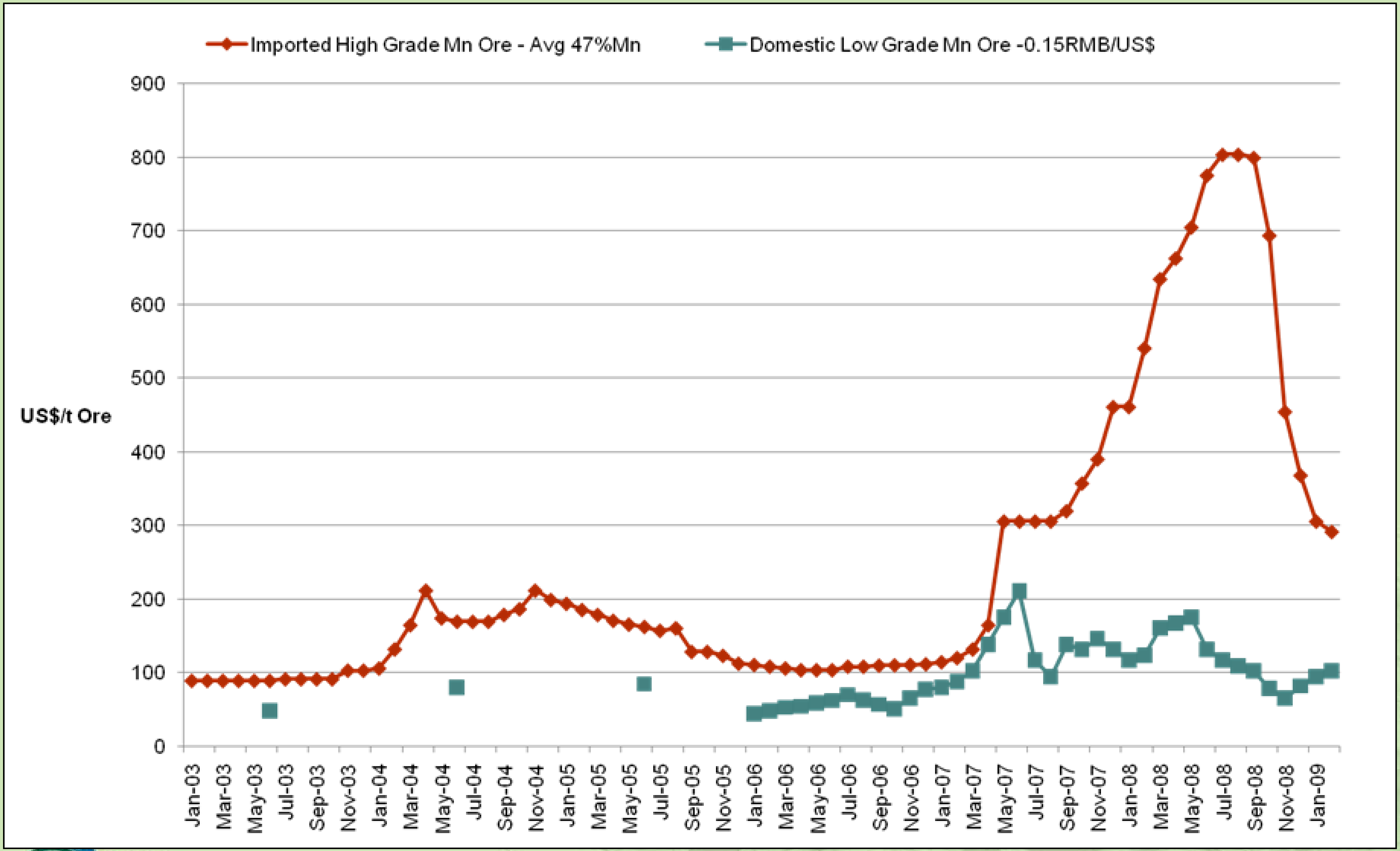
2.1.2每吨锰矿价格Mn Ore Price

红色-进口高品位矿石（平均47%），蓝绿-国内低品位矿石



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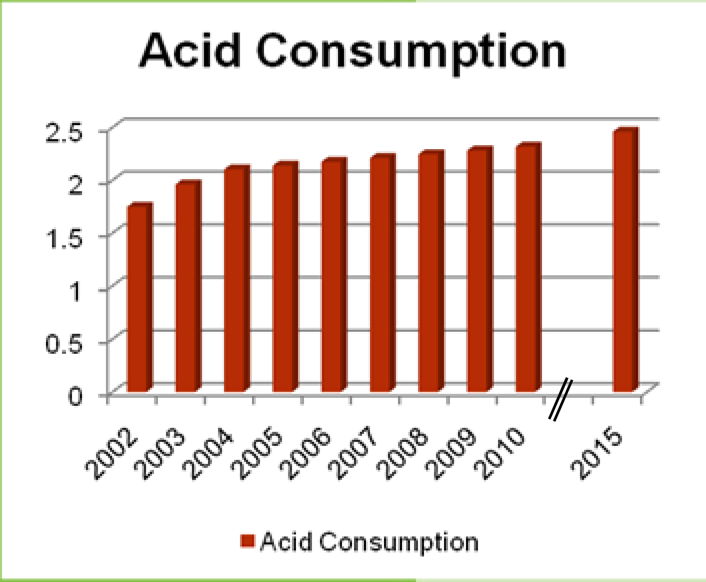
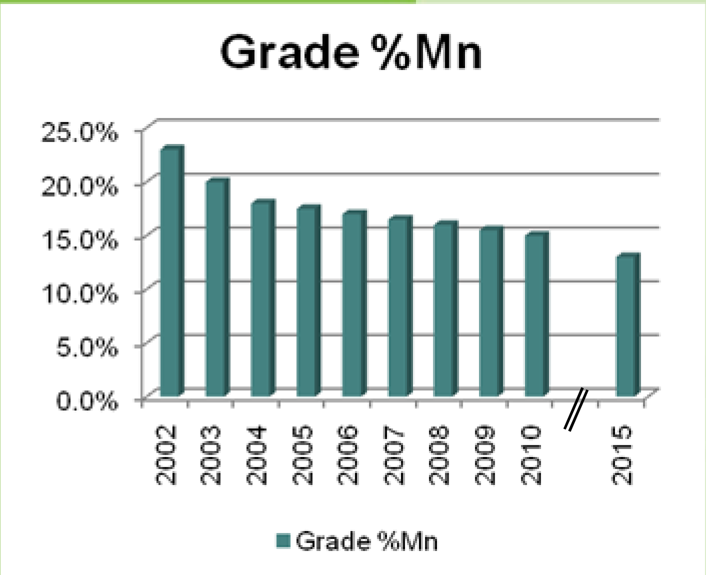
Source: Huacheng Electronic Exchange (www.hme01.com) and TEX Report

2.1.3 China's domestic Mn-ore grade is declining 中国国内锰矿的品位在不断下降





- Currently consuming 7-8 t ore/t EMM due to 30% decrease in grade since 2002 由于2002年以来锰矿品位降低了30%，现生产一吨EMM需要消耗7-8吨锰矿
- Rate of decrease is in the order of 0.5% Mn per year

  锰含量以每年0.5%的速度递减
- Currently in the order of 16% Mn

  目前的锰含量为16%

影响-一系列成本上升

- Acid consumption could increases by similar rate as grade decreases

  随着矿石品位的递减，用酸量也将以同样的速度递增
- Transport and milling cost will also increase as will the requirement for waste disposal space

  另外，运输和研磨的成本也会增加。还有就是会要求更多的废渣填埋场地。

2.2 High grade Mn ore -Process Aspects
高品位锰矿的生产过程

- Advantages:
  - Lower acid consumption (price of acid volatile)
    较低的用酸量 （化工用酸的价格很不稳定）
  - Higher Mn recovery can be achieved (up to 87% in RSA)
    可以达到更高的锰回收率（在南非高达87%）
  - Lower waste production/handling – lower capital for filter banks 更低的废渣处理成本 – 过滤机组的投入资本更低
- Disadvantages:
  - Require ore reduction 多了一个生产步骤：需要还原矿石
  - Additional process step and associated CAPEX and OPEX 额外的生产步骤和更高的相关资本支出及运营成本

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2.3 Waste Disposal Practice Comparison 三国矿渣处置做法比较 – 大纲

- Comparison - USA, Chinese and RSA:
  - Permitting 法律许可
  - Waste Classification 矿渣分类
  - Landfill Design Requirements 填埋场设计要求
  - Groundwater Monitoring and Standards 地下水监测和质量标准
  - Closure Requirements 封闭要求
- Examples of liner systems 衬层结构示例
- Disposal rates and costs 废渣处置速度和成本
  - Capex 资本支出
  - Opex 运营成本

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2.3.1.1 Permitting废渣处理的法律许可

USA	China	RSA
1. Resource Conservation and Recovery Act of 1976资源保护和回收法 Subtitle C: Hazardous Waste Management 副标题：危险废物管理	Standard for Pollution Control at General Industrial Solid Waste Disposal and Storage Sites. (GB 18599-2001) 一般工业固体废物贮存、处置场污染控制标准	Section 20 of the Environmental Conservation Act requires a waste disposal permit 环境保护法第20章规定废物处置须获许可证
2. Detailed Regulations by EPA, Title 40 of the Code of Federal Regulations 美国联邦环保署还公布了一些具体的细则， 联邦法规法典第40篇	Identification standard for dangerous wastes (GB5085.1-5085.2-1996) 危险废物鉴别标准	Minimum Requirements for the Classification, Handling and Disposal of Hazardous Waste, Department of Water Affairs, Second Addition 1998 南非水利部的危险废物分类、处理和放置最低要求法的1998年第二修订版
Require detailed site assessment and EIA 要求进行仔细的场地评估和环境影响评价	Integrated standard of wastewater discharge (GB8978-1996) 污水综合排放标准 Integrated standard of air pollution emission (GB16298-1996)大气污染综合排放标准	SABS 0228 Identification and Classification of Dangerous Substances and Goods SABS 0228危险物质和物品的鉴别和分类标准
	Integrated standard of air pollution emission (GB16298-1996)	
	Quality standard for groundwater (GB/T14848-93)地下水质量标准	
	Test method for leaching toxicity of solid waste (CB5086.1 50862.2 1997) 固体废物浸出毒性测定方法	

2.3.1.2 Waste Classification矿渣分类

USA	China	RSA
Must be a solid waste by definition 必须符合固体废物的定义 Waste can be excluded 有些废物可以排除在外，比如放射性的矿渣 There are listed wastes 有废物的列表/目录	Waste that is not listed in the National Catalogue of Dangerous Waste nor has hazardous characteristics as identified by leach tests, has to be subjected to waste characterisation tests and classification 没有列入国家危险废物目录，同时经浸出测试确认无危险特性的废物，必须进行废物特性测试和分类。	Waste sources are categorised based on SABS0228, the Basel Convention and the DWAF Minimum Requirements. 根据SABS0228危险物质和物品的鉴别和分类标准、巴塞尔公约及水利林业部最低要求对废物源进行分类，
All solid waste not excluded to undergo testing for: 所有的固体废物都必须经过测试，检测其 •Ignitability 易燃性 •Corrosivity ,腐蚀性 •Reactivity 反应性 •Toxicity (TCLP) 毒性 **事业废弃物毒性特性溶出程序**	Waste characterisation based on pH and leachable elements 废物特性以PH值和可浸出元素来定 Waste Classified as Type I and II wastes. 废物分成I类和II类 Waste disposal requirements based on waste class 不同的废物级别有不同的处置要求	All waste not already included in above list, undergoes Hazard Rating based on various test work including leaching characteristics. 根据各项测试工作包括浸出特性，对所有没有列入目录的废物进行危害分级 Hazard Rating is based on corrosivity, ignitability, toxicity, radioactivity, reactivity and involve the calculation of:
There are TCLP regulated substances of which Mn is not regulated (human health risk based) 基于人类健康危险，有一些物质是必须由TCLP管制的，但锰不包含在内 Can delist the waste based on pre-treatment 经过预处理的废物可从废物目录中除去	右边对应： • 环境浓度估计值和可接受风险程度的比较（要求提供物质的LC和LD50值） • 最大填埋率 • 最大的填埋量 • 可以通过预处理和提高处置率将废物降到较低的危险等级 • 锰的可接受风险程度是每升0.3毫克	• Estimated Environmental Concentration and comparison to ARL (require LC and LD50 values for substance) • Max loading/disposal rate • Max Total Load • Can delist the waste to a lower Hazard Rating using treatment and disposal rate. • ARL for Mn is 0.3mg/L

2.3.1.3 Landfill Design Requirements填埋场设计要求

USA	China	RSA
Follow a precautionary/prescribed approach with the option to follow a site specific Risk Based approach 可按照预防或规定的方法或是基于具体场地风险的方法设计填埋场	Only mention prescribed approach 仅提到可用规定的方法设计填埋场	Follow a precautionary/prescribed approach with the option to follow a site specific Risk Based approach可按照预防或规定的方法或是基于具体场地风险的方法设计填埋场
Require: 要求 •Double liner (bottom geocomposite) •双衬层：要求底部用土工复合材料 •Double leachate collection and removal 对渗滤液双层收集和清除 •Leak detection 泄漏检测 •Storm water control (25 year storm) 雨水控制 （要能抵挡25年一遇的洪水） •Air quality control 空气质量控制 •Construction quality assurance 建筑质量保证	Require: •Leachate collection and discharge facilities 渗滤液收集和排放设施 •Storm water control 雨水控制 •Type II require a prepared base with permeability of less than 1 x10^{-7}cm/s and thickness of 1.5m 对于第二类固体废物的填埋，要求有一个预先铺好的基底，其渗透系数需小于1 x10^{-7}cm/s，厚度需达到1.5米。 •Type II require leachate treatment facilities 对于第二类固体废物的填埋场，需要有沥出物处理设施	Require: •Double liner (upper geocomposite)双衬层：要求顶部用土工复合材料 •Double leachate collection and removal对渗滤液双层收集和清除 •Leak detection泄漏检测 •Storm water control (1:100 year storm event)雨水控制 （可抵挡百年一遇的洪水） •Air quality control空气质量控制 •Construction quality assurance 建筑质量保证 •Clay liners must have a lower outflow rate than 1 x10^{-7}cm/s 粘土衬层的排出流率/渗透系数需低于

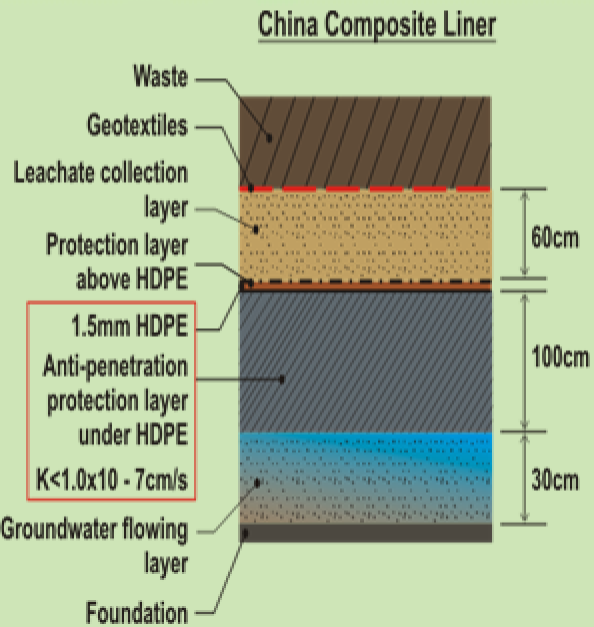
2.3.1.4 Groundwater Monitoring and Standards 地下水检测和标准

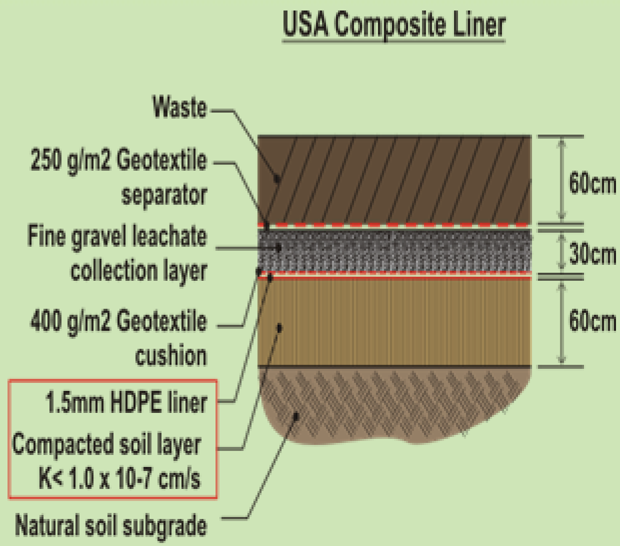
USA	China	RSA
Comprehensive groundwater monitoring for the following purposes: 进行综合地下水监控的目的：	More than 3 monitoring boreholes required, one upstream, one downstream and one in diffuse pathway 要求有3个以上检测井，上游、下游和扩散通路各设一眼	Comprehensive groundwater monitoring, including:综合性地下水检测，包括
• Detection monitoring (require at least 1 upstream and 3 downstream) 地下水检测井（要求至少在上游设一眼和下游设3眼检测） • Compliance monitoring监督是否符合规范 • Corrective action 不符合的进行纠正 • Need to establish site specific Groundwater Protection Standard • 需要建立具体场地地下水的保护标准 • Compliance point no more than 150m away from landfill or at extent of operator property 检测点与填埋场的距离不能超过150米，或者设在填埋场区的边界		•5-10 monitoring holes 5-10个检测井 •10-200m away from facility 与填埋设施相距10-200米 •Frequency and location to be determined by impact study 检测频率和地点取决于环境影响研究
Washington State groundwater quality 0.05mg Mn/L 华盛顿州的地下水质量标准：每升0.05毫克锰	Class 1&2 2mg Mn/L and Class 3 is 5mg Mn/L 一类和二类每升2毫克锰；3类每升5毫克锰	Acceptable Risk Level 0.3mg Mn/L 可接受的危险水平是每升地下水0.3毫克锰

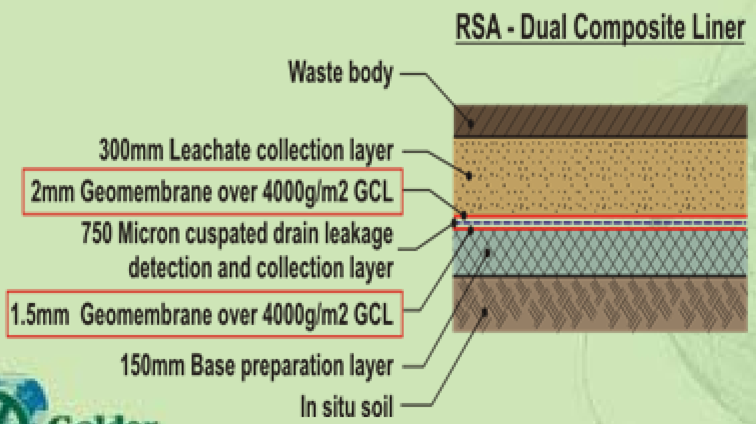
2.3.1.5Closure Requirements封场要求

USA	China	RSA
Require a closure Plan要提交一个封场计划	Require a Closure Plan 要提交一个封场计划	Require a Closure Plan
Cover to have a permeability equal or lower than bottom liner 封盖的渗透系数需等于或低于底部衬层渗透系数	Type I facility cover – soil with vegetation specific specification of thickness I类固体废物填埋场封盖要求–带有植被的土壤层，同时有具体的厚度要求 Type II facility cover – two layers, one compacted clay of 20-45cm thickness and covered by natural soil layer with vegetation specific specification of thickness II类固体废物填埋场封盖要求 – 两层，底层为厚度达20-45厘米的压实粘土层，上层为自然植被土壤层，有具体的厚度要求	Cover system prescribed to include: 规定封盖系统必须包括： •200mm soil layer •土壤层 •450mm clay layer •粘土层 •150mm base and gas drainage layer •地基和排瓦斯设备层
30 year post closure maintenance and monitoring 封场后持续进行30年的维护和检测	Care and maintenance until water quality has stabilised in the groundwater system.进行持续维护直到地下水系统的水质稳定	30 year post closure maintenance and monitoring封场后持续进行30年的维护和检测
Require financial assurance 要有资金保障		

2.3.2 Liner Design Examples衬层设计例子







- 中国复合衬层 – 表面水层，土工织物/地质纤维，渗滤液收集层，保护层，1.5mm高密度聚乙烯层，反渗透保护层（渗透系数），地下水流动层，地基。

- 美国 – 固体废物，土工织物/地质纤维分隔层，渗滤液细砾石收集层，密度为400g/m2的土工织物/地质纤维缓冲带， 1.5mm高密度聚乙烯层，压实泥土层（k?), 天然土壤路基。

- 南非双复合层 – 固体废物主体，300mm渗滤液收集层，2mm 土工膜再加密度为4000g/m2的澎润土复合防水垫 （GCL) , 750微米尖排水管渗漏检测和收集层，1.5mm土工膜再加密度为4000g/m2的澎润土复合防水垫 （GCL) , 150mm基底准备层，原生土层

2.3.3 Rates and Costs废渣处理速度和成本

Landfill	Opex (US$/t)	Capex (US$/$m^2$)
RSA, Nelspruit南非内尔斯普雷特	18-22	4.80-6.00
USA, Washington State	?	?
China example	?	?

Assuming a 10 000t/a EMM Factory 例如一个年产量达１万吨的ＥＭＭ工厂		
Mn Ore Grade	**Waste (t/a)**	**Landfill Space (m^2/a)**
Low Grade – China	76 806 (1)	4 500 (3)
High Grade - RSA	16 738 (2)	990 (3)

1. Assume 16%Mn ore and factory efficiency of 72%
2. Assume 44%Mn ore and factory efficiency of 85%　工厂效率
3. Assume 10m high Mn waste disposal facility　10米高的锰矿渣填埋设施

How much landfill space is available?还有多少填埋场地可用呢？
At 900 000t/a require 405 000m^2/a (40.5 ha/a) waste disposal footprint growth　以年产量９０万来算，每年要新增40.5万平方米或40.5公顷的废渣填埋场地

3. Scenario Evaluation案例分析/对比分析

Scenario descriptions (low vs high grade ore as a function of EMM production cost)
案例描述（使用高低品位锰矿生产电解锰的成本对比）

- All things equal, current case 所有成本要素不变
- All things equal, change in ore grade除锰矿品位变化外，其它成本要素不变
- All things equal, change in ore grade and stricter waste disposal enforcement 除锰矿品位变化和提高废渣处理标准外，其它成本要素不变

- Scenario comparison (Table and results) 案例对比（图表和对比结果）

Key Inputs to EMM production:成本要素
- Mn ore 锰矿
- Sulphuric acid 硫酸
- Ammonia 氨水
- SeO_2 or SO_2 二氧化硒 或二氧化硫
- Electricity 电力
- Materials (e.g. cathodes) 其他原料如阴极等
- Labour 劳力

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Base or Current Case

Example for EMM industry	Low grade ore	High grade ore	Unit
Mn content 锰含量	16	44	
Ore price (powder, DEL)矿粉价格	550	2690	RMB/t ore
Overall factory efficiency工厂总效率	72	85	%
Ore consumption 矿石消耗量	8.68	2.67	t/t EMM
Ore reduction cost 矿石还原成本	0	360	RMB/t ore
Acid consumption 用酸量	2.32	0.25	t/t EMM
Acid price 化工用酸价格	450	450	RMB/t acid
Waste generation (dry basis) 所产废渣（干重）	7.68	1.67	t/t EMM
Cost to dispose waste 废渣处理成本	50	50	RMB/t waste
Cost of ore	4,774	8,155	RMB/t EMM
Cost of acid	1,044	113	RMB/t EMM
Cost of disposal of waste	384	84	RMB/t EMM
Total cost of above	**6,202**	**8,351**	**RMB/t EMM**
For 10,000tpa EMM factory: 年产量１万吨			
Volume of waste to landfill	**76,806**	**16,738**	**t waste**
Cost saving to the EMM factory when using low grade: 与高品位矿相比，降低２６％			**26%**
Difference in waste mass to landfill:增加3.59倍			**359%**

Source of price from Huacheng Electronic Exchange website. Price basis is for ore that has been milled to powder already, delivered to the EMM factory, ready for leaching 锰矿价格来源于华诚金属交易网，这里指的是已研磨成矿粉，送到ＥＭＭ工厂，随即可进行矿石浸出的锰矿价格

Generally accepted industry average for low grade ore in China EMM 在用低品位锰矿生产ＥＭＭ的中国厂家中普遍接受的行业平均值

Mass balance and stochiometry based estimate 基于物料均衡和化学计量学的估计

Source of price from Huacheng Electronic Exchange website. Price basis is for 98% acid, delivered 价格来源于上海华诚金属交易网，指的是浓度为９８％的化工用酸价格

Estimate based on limited waste handling (short distance mechanical) 基于有限的废渣处理（即短距离的机械处理）而估计的成本

Imported ore price inside ports China in RMB/mtu as per website such as Asian Metal, times Mn content %, plus transport in RMB/t across average distance from east coast to Mn-Triangle in south-west China, plus milling cost as claimed by various producers.中国港口进口锰矿价格是按照亚洲金属网之类的网站所报的每公吨度价格，乘以锰含量的百分比，再加上以中国东岸到中国西南部锰金三角平均距离计算的运费，并加上研磨费而得出的价格

General accepted industry average for high grade ore in South Africa 南非高品位锰矿生产普遍接受的行业平均值

Estimated cost of operating a reduction kiln, electricity and reductant (coal or oil) cost in South Africa 所估计的成本包括在南非还原回转炉的操作成本、用电以及还原剂（煤或石油）的成本

General accepted industry average for high grade ore in South Africa南非高品位锰矿生产普遍接受的行业平均值

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Decreasing Grade

Example for EMM industry	Low grade ore	Low grade ore	Low grade ore	High grade ore	Unit
Mn content	20	15	10	44	%
Ore price (powder, DEL)	550	550	550	2690	RMB/t ore
Overall factory efficiency	72	72	72	85	%
Ore consumption	6.94	9.26	13.89	2.67	t/t EMM
Ore reduction cost	0	0	0	360	RMB/t ore
Acid consumption	1.96	2.32	2.67	0.25	t/t EMM
Acid price	450	450	450	450	RMB/t acid
Waste generation (dry basis)	5.94	8.26	12.89	1.67	t/t EMM
Cost to dispose waste	50	50	50	50	RMB/t waste
Cost of ore	3,819	5,093	7,639	8,155	RMB/t EMM
Cost of acid	882	1,044	1,202	113	RMB/t EMM
Cost of disposal of waste	297	413	644	84	RMB/t EMM
Total cost of above	**4,999**	**6,550**	**9,485**	**8,351**	**RMB/t EMM**
For 10,000tpa EMM factory:					
Volume of waste to landfill	**59,444**	**82,593**	**128,889**	**16,738**	**t waste**
Cost saving to the EMM factory when using low grade:	40%	22%	-14%		
Difference in waste to landfill:	255%	393%	670%		

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Standard Waste Disposal Practices

Example for EMM industry	Low grade ore	Low grade ore	Low grade ore	High grade ore	Unit
Mn content	20	16	10	44	%
Ore price (powder, DEL)	550	550	550	2690	RMB/t ore
Overall factory efficiency	72	72	72	85	%
Ore consumption	6.94	8.68	13.89	2.67	t/t EMM
Ore reduction cost	0	0	0	360	RMB/t ore
Acid consumption	1.96	2.32	2.67	0.25	t/t EMM
Acid price	450	450	450	450	RMB/t acid
Waste generation (dry basis)	5.94	7.68	12.89	1.67	t/t EMM
Cost to dispose waste	150	150	150	150	RMB/t waste
Cost of ore	3,819	4,774	7,639	8,155	RMB/t EMM
Cost of acid	882	1,044	1,202	113	RMB/t EMM
Cost of disposal of waste	892	1,152	1,933	251	RMB/t EMM
Total cost of above	**5,593**	**6,970**	**10,774**	**8,519**	**RMB/t EMM**
For 10,000tpa EMM factory:					
Volume of waste to landfill	**59,444**	**76,806**	**128,889**	**16,738**	**t waste**
Cost saving to the EMM factory when using low grade:	34%	18%	-26%		
Difference in waste to landfill:	255%	359%	670%		

Conclusions

High grade Mn ore: Can it influence the cost of future EMM production?高品位锰矿能否左右未来ＥＭＭ的生产成本?

- Grade in local $MnCO_3$ ore can decrease to levels where high grade ore is more economical to use (all things equal)中国国内的碳酸盐锰矿石品位会持续下降，成本优势逐渐减少，以致将来有一天使用高锰矿的生产ＥＭＭ的成本会更低。（前提是其他成本要素不变的情况下）
- Use of high grade ore has lower waste volumes to handle and dispose

  使用高品位锰矿生产，需要处理和填埋的矿渣数量更少
- Waste disposal practices in China will likely require higher future compliance to China standards with resultant increase in future waste disposal costs

  对于固体废物得处置方法，未来中国将会出台更高的标准，因而将来废渣处理的成本会升高。

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Thank You for your Attention!

Questions?

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