Olympic Dam Geology – New Insights

Kathy Ehrig (Principal Geometallurgist) and Jesse Clark (Mine Geologist)
8 December 2017: South Australian Exploration and Mining Conference
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Mineral Resources


All reports are available to view on www.bhpbilliton.com.

Olympic Dam Mineral Resources are reported by Shane O’Connell (MAusIMM). Escondida and Antamina Mineral Resources are compiled by Martin Williams (MAusIMM).

The Company confirms that it is not aware of any new information or data that materially affects the information included in the original market announcements and, in the case of estimates of Mineral Resources, that all material assumptions and technical parameters underpinning the estimates in the relevant market announcements continue to apply and have not materially changed. The Company confirms that the form and context in which the Competent Persons’ findings are presented have not been materially modified from the original market announcements.

The above-mentioned persons are full-time employees of BHP, and have the required qualifications and experience to qualify as Competent Persons for Mineral Resources under the 2012 edition of the JORC Code. The compilers verify that this presentation is based on and fairly reflects the Mineral Resources information in the supporting documentation and agree with the form and context of the information presented.

Statement of Mineral Resources

Copper Operations BHP interest 30 June 2017 Resource Measured Resources Indicated Resources Inferred Resources Total Resources

<table>
<thead>
<tr>
<th>Ore Type</th>
<th>Tonnages millions</th>
<th>Cu %</th>
<th>U₃O₈ kg/t</th>
<th>Au g/t</th>
<th>Ag g/t</th>
<th>Mo ppm</th>
<th>Zn %</th>
<th>Tonnages millions</th>
<th>Cu %</th>
<th>U₃O₈ kg/t</th>
<th>Au g/t</th>
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<th>Au g/t</th>
<th>Ag g/t</th>
<th>Mo ppm</th>
<th>Zn %</th>
</tr>
</thead>
</table>
| Olympic Dam 100 Sulphide 1,460 0.96 0.30 0.41 2 - - 4,680 0.79 0.25 0.34 1 - - 3,920 0.71 0.24 0.28 1 - - 10,100 0.78 0.25 0.33 1 - -
| Escondida 57.5 Sulphide 5,350 0.63 - - - - - 3,510 0.57 - - - - - 9,570 0.51 - - - - - 18,400 0.56 - - - - -
| | Oxide 104 0.69 - - - - - 83 0.57 - - - - - 20 0.53 - - - - - 207 0.63 - - - - -
| | Mixed 70 0.62 - - - - - 82 0.47 - - - - - 59 0.44 - - - - - 211 0.51 - - - - -
| Escondida (Pampa Escondida) 57.5 Sulphide 294 0.53 - 0.07 - - - 1,150 0.55 - 0.10 - - - 6,000 0.43 - 0.04 - - - 7,440 0.45 - 0.05 - - -
| Escondida (Pinta Verde) 57.5 Sulphide - - - - - - - 23 0.50 - - - - - 37 0.45 - - - - - 60 0.47 - - - - -
| | Oxide 109 0.60 - - - - - 64 0.53 - - - - - 15 0.54 - - - - - 188 0.57 - - - - -
| Escondida (Chimborazo) 57.5 Sulphide - - - - - - - 139 0.50 - - - - - 84 0.60 - - - - - 223 0.54 - - - - -
| Antamina 33.75 Sulphide Cu only 155 0.89 - - 7 330 0.14 517 0.86 - - 8 260 0.15 816 0.82 - - 8 240 0.14 1,490 0.84 - - 8 260 0.14 - -
| | Sulphide-Cu-Zn 75 0.94 - - 17 100 1.91 322 0.92 - - 15 80 1.80 430 0.98 - - 15 80 1.50 827 0.95 - - 15 80 1.66 - -

Metal equivalents

The metallurgical recoveries and price information used to calculate copper equivalent figures in this presentation that relates to the FY2017 Mineral Resources (inclusive of Ore Reserves) were sourced from and can be found in the 2017 BHP Annual Report of September 2017 and the 2017 United States Securities and Exchange Commission Form 20-F.

All reports are available to view on www.bhpbilliton.com.

Copper equivalent grade calculations for BHP assets are listed below.

Olympic Dam: CuEq = Cu % + (U₃O₈ kg/t x 0.901) + (Au g/t x 0.504) + (Ag g/t x 0.0066); Escondida: CuEq = Cu % + (Au g/t x 0.687); Antamina: CuEq = Cu % + (Zn % x 0.38) + (Mo % x 1.99) + (Ag g/t x 0.0082); Molybdenum price used = US$7.41/lb.
Today’s Presentation

Part 1
Olympic Dam – Update
A few slides from the Investor and Analyst Briefing* (Adelaide) – 28 November 2017

Part 2
Olympic Dam Geology – New Insights
Geological drilling, logging, mapping and research continue.

• Refer to https://www.bhp.com/-/media/documents/media/reports-and-presentations/2017/171128_mineralsaustraliaupdateandolympicdambriefing.pdf?la=en
Part 1

Olympic Dam – Update
A few slides from the Investor and Analyst Briefing* (Adelaide) – 28 November 2017

# Staged resource development strategy

## Resource development via staged, independent, investment options, subject to strict capital allocation framework tests

1. **Stabilise base operations**  
   IRR >50%¹

   - De-bottleneck mine, focus on productivity and stability
     - Mine expansion into Southern Mine Area (SMA)
     - Restore operational stability
       - largest planned smelter shut
       - refinery upgrade
       - Whenan hoist refurbishment
       - new tailings storage facility

2. **Brownfield expansion option (BFX)²**  
   IRR >20%¹

   - Capital efficient increase in capacity
     - BFX being studied
       - smelter capacity upgrade
       - new refinery tankhouse
       - additional milling capacity
     - Accelerate mine development, associated infrastructure

3. **ODEP optionality²**  
   Studies underway

   - Potential to transition to a low cost, high-volume operation
     - Large scale underground and greenfield surface expansion
     - Possible heap leach

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<table>
<thead>
<tr>
<th>FY18e</th>
<th>FY19e</th>
<th>FY20e</th>
<th>FY21e</th>
<th>FY22e</th>
<th>FY23e</th>
<th>Long-term</th>
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<tbody>
<tr>
<td>150</td>
<td>215</td>
<td></td>
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<td></td>
<td></td>
<td>280</td>
<td>~300</td>
<td>~450</td>
<td>~500</td>
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<tr>
<td>First ore from SMA; SCM</td>
<td>Re却 upgrade</td>
<td>Whenan refurbishment</td>
<td>SCM; Tailings storage facility</td>
<td>BFX; SMA MHS Stage 1</td>
<td>BFX; SMA MHS Stage 2</td>
<td></td>
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## Production guidance (Cu ktpa)  

<table>
<thead>
<tr>
<th>FY18e</th>
<th>FY19e</th>
<th>FY20e</th>
<th>FY21e</th>
<th>FY22e</th>
<th>FY23e</th>
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## Indicative capacity (Cu ktpa)

<table>
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<th>FY18e</th>
<th>FY19e</th>
<th>FY20e</th>
<th>FY21e</th>
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1. At consensus price and exchange rate forecasts.
2. Subject to internal and third party approvals.

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Olympic Dam: A world-class resource with valuable optionality  
28 November 2017
A unique resource with valuable optionality

- Large, polymetallic ore body: 10.1 Bt at 0.78% Cu (1.18% CuEq)\(^1,2\)
  - third largest copper equivalent deposit in the world
  - largest uranium and third largest gold deposit
  - resource remains open at depth, offering potential upside
- High-grade ore body, suited to selective underground mining
  - >1 Bt of minable underground material
  - Cu grade projection increasing to ~3% (~4.2% CuEq)\(^1\)
  - Cu grade to average >2.5% (~3.6% CuEq)\(^1\) over next 30 years
- Largely untapped, particularly in the Southern Mine Area (SMA) which represents ~70% of remaining resource
- Supports medium and long-term optionality

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1. Copper equivalent resource and grade figures calculated per metal equivalents note on slide 3.
2. Breakdown by Resource classification is provided on slide 3.
4. Olympic Dam previous plan represents underground mine plan using traditional grade estimation.

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Olympic Dam: A world-class resource with valuable optionality
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Resource modelling supports more efficient development

**Increased understanding supports optimal mine development**

- Ore body is well defined (>3,200 km resource drilling in over 11,000 drill holes, >1 million drill core samples)

- Geostatistical algorithms improved our understanding of the grade variability through the resource
  - identified significant volumes of high-grade ore (>2.5% Cu)
  - suited to selective sub-level open stoping (SLOS)

- Optimal resource development strategy leverages grade variability
  - tailored stope design
  - sequence stopes to prioritise high-grade ore first

- Development strategy improves overall resource recovery and capital efficiency, while lowering operating costs to maximise investment returns

- Preserves optionality for future development scenarios
  - defer lower-grade ore for a transition to a high-volume strategy
Olympic Dam Geology – New Insights

Geological drilling, logging, mapping and research continue.

Acknowledgements

BHP Olympic Dam
• Resource Geology
• Mine Geology

University of Tasmania
• Dima Kamenetsky
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• CODES Laser Ablation Facilities

University of Adelaide
• Nigel Cook
• Cristiana Ciobanu
• PhD Students: Alkis Kontonikas-Charos (completed), Sasha Kneeta (completed), Liam Courtney-Davies, Max Robert Verdugo IhI, Marija Dmitrijeva, William Keyser, Danielle Schmandt, Mark Rollog

University of Melbourne - Roland Maas
CSIRO Land and Water, Adelaide - Mark Raven

ARC Linkage LP130100438 - The supergiant Olympic Dam uranium-copper-gold rare earth element ore deposit: towards a new genetic model

South Australian Mining and Petroleum Services Centre of Excellence (Department of State Development)
• Trace elements in iron oxides project
• Copper Uranium Hub project (joint ARC project IH130200033)
Definition drilling for BFX
2018 to 2022 stope definition drilling
2023 to 2027 stope definition drilling
2028 to 2032 stope definition drilling
New Geological Data = New Interpretations

2016-17 Structural interpretation (in progress)
Jesse Clark and Nick Poznik and other OD Mine Geologists

Cu (wt%) -450mRL

-450mRL
ODBC Components: Bedded Clastic Facies

McPhie et al. (2016) and Cherry et al. (2017)

Polymict conglomerate: KFMU

contains ~1590 Ma zircons

contains ~1590 Ma zircons

Brecciated, quartz-rich sandstone: KGRN (“Pandurra-like”)

*** contains ~1590 Ma and OLDER zircons ***

Felsic, hem-qtz sandstones/mudstones: KHEMQ

contains ~1590 Ma zircons

Mafic, chi-qtz sandstones/mudstones: KASH

contains ~1590 Ma zircons

Mudstones, variable hem-alteration: VASH

contains ~1590 Ma zircons

RD2919B 682-690m

RD1989 611-623m

RD1989 458-466m

RD3449 398-406m

RD2751 860-868m

contains ~1590 Ma and OLDER zircons
McPhie et al. (2016) and Cherry et al. (2017)
OD-VASH

McPhie et al. (2016) and Cherry et al. (2017)
McPhie et al. (2016) and Cherry et al. (2017)
McPhie et al. (2016) and Cherry et al. (2017)
**Profound Implications:**

- Are the “Pandurra-like” sandstones actually Pandurra?
- If the diagenetic age of the Pandurra is ~1424 Ma, what event caused their incorporation into the ODBC?

**AUDIENCE QUESTION:** any other possibilities on what the quartz-rich sandstones are?
VBx = volcanic breccias
KFMU = polymict conglomerate
VASH = hm-rich sediments
KASH = mafic sediments
KHEMQ = felsic sediments
KGRN = well sorted sandstones ("Pandurra-like")
HEMQ = hem-qtz breccia

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Simplified Geological Plan (-350mRL)

Olympic Dam Geology – New Insights

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Fe-oxide $^{207}\text{Pb-}^{206}\text{Pb}$ dating

Magnetite (Ciobanu et al. 2014)

The presence of U (and radiogenic Pb) in Fe-oxides raises the potential for novel geochronology applications aimed at constraining the timing of mineralization. $^{207}\text{Pb/}^{206}\text{Pb}$ ages obtained on zoned hematite (1590 ± 8 and 1577 ± 5 Ma; Ciobanu et al. 2013) are consistent with a major ore-forming event tied to magmatism in the region at ~1.59 Ga (e.g., Skirrow et al., 2007). New data on zoned magnetite shows older $^{207}\text{Pb/}^{206}\text{Pb}$ ages (1769 ± 58 Ma) concordant with an earlier, BIF-type origin.

Implications:

- RDG probably intruded Wallaroo Group metasediments.
- Which metals or ligands might have been sourced from the metasediments?
- Are all of the sediments in the deposit actually pre-1590 Ma but with 1590 Ma hydrothermal zircons instead of 1590 Ma detrital zircons (Ciobanu, personal communication, 2017)?
Uraninite dating (LA-ICP-MS)

Intercepts at
-31±37 & 1594.4±3.1 [±6.3] Ma
MSWD = 0.99

Intercepts at
470±13 Ma
MSWD = 1.5

Intercepts at
568±33 Ma
MSWD = 2.8

Macmillan et al. (2016), Apukhtina et al. (2017), unpublished data
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OD Sulfides - $^{207}\text{Pb-}^{206}\text{Pb}$ dating(?)

Sulfides record NO release of uranogenic Pb
($^{207}\text{Pb}/^{206}\text{Pb} \sim 0.115$) from the ~1600 Ma uraninite
(Kamenetsky, unpublished data)
Zircon: CA-ID-TIMS (unpublished)

Alex Cherry – manuscript to be submitted within a few weeks

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Jagodzinski (2016 AESC): zircon CA-ID-TIMS ages
Summary and Conclusions

Many questions about the timing of events at Olympic Dam remain unresolved and are very controversial (even within our research group):

- The main Cu-U-Au-Ag mineralising event at Olympic Dam was ~1590 Ma (no question).
- Age of the sediments within the ODBC and timing of their incorporation into the ODBC remains unresolved.
- Remobilisation of ~1590 Ma uranium until the Delamerian. Significant addition of uranium into Olympic Dam during the Delamerian.

A common characteristic of super giant ore deposits, is upgrading via secondary enrichment, post initial ore formation. Why should Olympic Dam be an exception?