

**BACKGROUND of PHILLIP HELLMAN  
WITH RESPECT TO EVALUATION and RESOURCE ESTIMATION of RARE EARTH  
and RARE METAL DEPOSITS**

**Summary**

*Dr Phillip Hellman (BSc Hons 1, PhD, Fellow AIG) is an Associate of Behre Dolbear Australia and an Associate of H&S Consultants Pty Ltd with more than 40 years of experience as a professional geologist. Dr Hellman is the former Managing Director of Hellman and Schofield Pty Ltd. He has worked on numerous rare earth projects in Australia, Asia, Africa, India, Madagascar, Mongolia, Saudi Arabia and USA. He is the author of various specialist academic and applied papers on rare earth deposits and has presented to the EURARE, the European rare earth industry's specialist organisation. He is a Competent Person under the JORC Code.*

*Dr Hellman undertook postgraduate (PhD) studies in experimental petrology and geochemistry at Macquarie University and University of Cambridge (UK) from 1975 to 1978. Papers from this work were published in a number of journals including Nature, Contributions to Mineralogy and Petrology, Earth and Planetary Science Letters and Royal Society of NSW. A major part of his Ph D was concerned with neutron activation analysis of rare earth elements and electron probe microanalysis. This research resulted in the documentation of the mobility of REE in a variety of geological environments and disproved the then current view that REE were largely immobile during alteration processes.*

**Detail**

***Mt Weld, Western Australia, Lynas Corporation***

This is the richest known rare earth deposit in the world with an initial (2002) published total resource of 12.2 mt at 9.7% REO (2.5% cut-off). The current (2022) resource stands at 54.7 Mt grading 5.3% TREO for 2.9 Mt of contained TREO. Ore Reserves are 18.6 Mt grading 8.2% TREO for 1.5 Mt of contained TREO. The mineralisation is associated with the Mt Weld carbonatite and has originated due to a lengthy duration of supergene processes that have concentrated REE in various minerals such as monazite, apatite, churchite and crandallite.

Dr Hellman undertook the original geological modelling and resource estimation of both the Central Lanthanide Deposit (“CLD”) at Mt Weld in early 2002 as well as the rare metals’ project. Grade control drilling and mining of the CLD began in 2006 and 2007 with the resource estimates proving to be within approximately 1% of actual mined tonnes and grades.

The rare metals project consists of Ta, Nb, REE, Zr, Fe, P, Al and Ti mineralisation within the Coors, Crown and Swan deposits. Estimates for all the oxide equivalents of the elements listed were completed and reported above a zero value cut-off.

<http://www.lynascorp.com>.

***Nolans Bore, Northern Territory, Australia, Arafura Resources***

Dr Hellman managed and provided peer review for the 2009 resource estimates of the phosphate – rare earth element deposit at Nolans Bore. The 2009 published resource was 30 mt at 2.8% REO and 12.9% P<sub>2</sub>O<sub>5</sub> (1.20% REO cut-off). The current (2017) resource stands at 56 Mt grading 2.6% TREO and 11% P<sub>2</sub>O<sub>5</sub> for 1.5 Mt of contained TREO. The mineralisation is hosted

in fluorapatite, cheralite, monazite, allanite and bastnasite. The mineralised zones are characterised by fluorapatite veins or as stockworks with calc-silicate alteration.

<http://www.arafuraresources.com.au/>.

### ***Cummins Range, Western Australia, (originally owned by Navigator Resources)***

Dr Hellman completed the 2009 resource estimates of the REO-uranium-phosphate monazite mineralization which is up to 50m in thickness and is mainly developed in a sub-horizontal geometry within deeply weathered regolith developed over carbonatite and pyroxenite rocks. At a 1.0% REO cut-off a total resource of 4.2mt at 1.7% TREO for 72Kt of contained TREO was estimated. The current resource is 6.5 Mt at 2.0% (1.0% TREO cut-off).

[http://anovametals.com.au/wp-content/uploads/2012/12/KRE\\_Presentation\\_December\\_2011.pdf](http://anovametals.com.au/wp-content/uploads/2012/12/KRE_Presentation_December_2011.pdf)

<https://www.rarex.com.au/projects-cummins-range>

### ***Mountain Pass, California, USA***

Dr Hellman completed due diligence resource estimates of the dominantly carbonatite and bastnasite-hosted Mountain Pass deposit for a potential acquisition. Published resources are approximately 20mt at 7% REO.

<http://geology.csupomona.edu/drjessey/fieldtrips/mtp/mtnpass.htm>.

<http://www.molycorp.com/>

### ***Kundaybayskoe Heavy Rare Earth Deposit, Kazakhstan***

Dr Hellman evaluated the Kundaybayskoe (or Kundaybay) rare earth deposit which is approximately 60 km from the mining centre of Gitigara , 50 km from the Russian border, in the north-western part of Kazakhstan. Dr Hellman was retained to check the existing resource estimates produced under the Russian classification system. The mineralisation is heavy rare earth dominated and is hosted by an interesting rare earth phosphate with a potentially low cost recovery process. The existing information was computerised and the first non-Russian type resource estimate was completed. A detailed assessment and comparison with the Russian estimates was made to help a potential joint-venturer (US hedge fund) assess the deposit.

### ***Confidential Alkaline Intrusive Hosted Rare Earth Deposit, Mongolia***

Dr Hellman completed resource estimation and coordination of mineralogical and metallurgical studies of an alkaline-hosted intrusive rare earth deposit in Mongolia. The britholite-hosted deposit is light rare earth enriched and similar to Ce-enriched apatite mineralisation.

### ***Kvanefeld REE-U-NaF deposit, Greenland***

Dr Hellman assisted with, and provided peer review for the resource estimation of Kvanefjeld which is an emerging U-REE-Zn deposit hosted within marginal phases of the Ilimaussaq Intrusive Complex, located near the southwest tip of Greenland. The published total resource at the time was, at a 0.015% U<sub>3</sub>O<sub>8</sub> cut-off, 1.01 Bt at 0.027% U<sub>3</sub>O<sub>8</sub>, 1.1% REO and 0.24% Zn. NaF is also associated with the rare earth mineralisation and has a separate resource estimate.

<http://www.ggg.gl>.

### ***Kangankunde Rare Earth Deposit, Malawi***

Dr Hellman completed resource estimates for the Kankankunde carbonatite hosted deposit in Malawi. The mineralisation is dominantly hosted by a heavy mineral that is amenable to low cost gravity processing. Total published resources are 2.5 mt at 4.2% REO (3.5% cut-off).

[http://www.lynascorp.com/content/upload/files/Announcements/Acquisition\\_of\\_New\\_Rare\\_Earths\\_Resource\\_in\\_Malawi\\_060907\\_\(2\).pdf](http://www.lynascorp.com/content/upload/files/Announcements/Acquisition_of_New_Rare_Earths_Resource_in_Malawi_060907_(2).pdf).

### ***Ngualla Rare Earth Deposit, Tanzania***

Dr Hellman assisted with, and provided peer review for Peak Resources who discovered extensive Rare Earth Oxide (REO), niobium-tantalum and phosphate mineralisation within the Ngualla Carbonatite in southern Tanzania. The Ngualla Carbonatite is a roughly circular volcanic pipe with a diameter of approximately 3.8km. Some of the mineralisation at Ngualla is similar in style to that at Mt Weld in Western Australia and Zandkopsdrift in South Africa, being REO, phosphate and tantalum – niobium enrichment in a deeply developed regolith profile above a large carbonatite. Mineralisation is also contained in extensive alluvial deposits around these central hills of weathered carbonatite.

<http://www.peakresources.com.au/>

<http://www.peakresources.com.au/exploration/tanzania/projects/ngualla.aspx>

### **Miscellaneous involvement:**

Sundry confidential rare earth deposits in Saudi Arabia involving assessment of quality of data and assessment of Saudi practices, 2015-17.

Evaluation of the Kamthai Nd-Pr deposit, Kamthai, India, 2015.

Assessment of the Tantalus rare earths ionic clay project, Madagascar, 2017-18.

Assessment of an emerging NdPr project in Western Australia, 2018-present.

Provision of technical advice for various secondary clay and supergene-hosted and potential Ionic Adsorption Deposits in SE Asia and Australia.

Assessment of an emerging xenotime project Australia, 2021-present.

Assessment of a REE-rare metal (Zr, REE, Hf, Ta, Nb) project, 2021-present for potential investment by a major mining company.

### **Publications Relating to Rare Earths**

#### ***Internationally refereed***

Hellman, P. L. and Duncan, R. K., 2014: Evaluation of rare earth deposits. *Applied Earth Science (Trans. Inst. Min. Metall. B)*. 2014 Vol 123 No. 2

Hellman, P. L. and Henderson, P., 1977: Are rare earths mobile during spilitization [ie alteration]? *Nature*, 267, pp 191 – 201

Hellman, P. L. and Henderson, P., 1977: Geochemical [ie REE] and stratigraphic evidence against an oceanic crust interpretation for the Tumut “greenstone” occurrence. *J Geol Soc Aust*, 24, pp 215 - 218

Hellman, P. L., Smith, R. E. and Henderson, P., 1979: Rare earth element investigation of the Cliefden Outcrop, N.S.W., Australia. *Contrib. Mineral. Petrol.*, 65, pp 155 – 164.

Hellman, P. L., Smith, R. E. & Henderson, P., 1979: The mobility of the rare earth elements: evidence and implications from selected burially metamorphosed terrains. *Contrib. Mineral. Petrol.*, 71, pp 23 – 44.

### ***Conference papers***

Hellman, P. L., 2015: The Evaluation of rare earth and rare metal deposits. Rare Earth and Rare Metal Resources from Carbonatites Alkali Granites and Pegmatites of India: theory. Geological Society of India (GSI), Bengaluru and the Atomic Minerals Directorate (AMD), Department of Atomic Energy, Govt of India, Begampet, Hyderabad – 16.

Hellman, P. L. and Duncan, R. K., 2017: Evaluation of rare earth deposits. *ERES2017: 2<sup>nd</sup> European Rare Earth Resources Conference, Santorini, May 2017.* <http://www.eurare.eu/news.html>  
<http://eres2017.eresconference.eu/program/>

Hellman, P. L. and Duncan, R. K., 2018: Evaluating rare earth deposits. *Australasian Exploration Geoscience Conference (AEGC) February 2018*

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