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Defence Science and Technology Group

Ballistic testing of an ultra-high hardness steel

Shannon Ryan[1], Huijun Li[2,5], Mark Edgerton[3], Denver Gallardy[4], Stephen Cimpoeru[5]

[1]Defence Science and Technology Group, Melbourne, Australia

[2]Faculty of Engineering and Information Sciences, University of Wollongong, Australia

[3]Faculty of Engineering, Architecture and Information Technology, University of Queensland, Australia

[4]U.S. Army Research Laboratory, Aberdeen Proving Ground, USA

[5]Defence Materials Technology Centre, Hawthorn, Australia

29th International Symposium on Ballistics

Edinburgh, 9-13 May 2016

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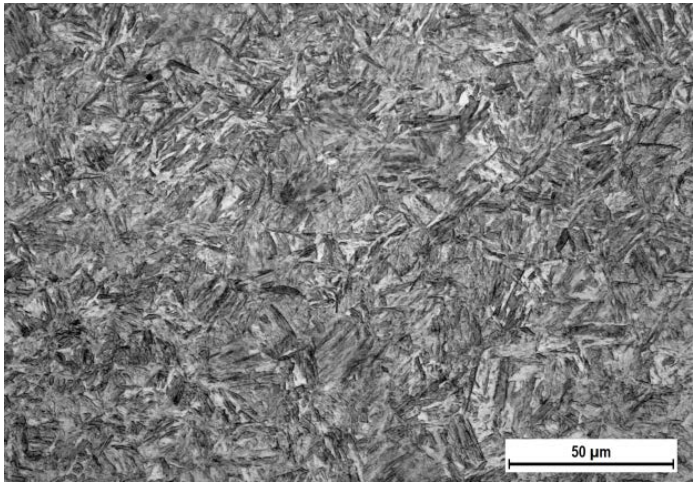
Introduction & Overview

- Ultra High Hardness Armour (UHA) steels, i.e. >570 HB, have shown high performance against small cal AP projectiles
- Bisalloy Steels Pty Ltd. (Australia) produce a quenched and tempered UHA steel – BIS UHH
- Evaluated UHH against both AP and FSP projectiles
- Compare the performance with other armour steel grades



BIS UHH microstructure

Hardness (HB)	0.2% Proof Stress (MPa)	Tensile Strength (MPa)	Elongation (%)	Charpy V-notch (J)
570-640	1500	2050	8	min. 8*

*In accordance with AS 1544.2, -40°C, transverse, 10×10 mm sample

Test overview

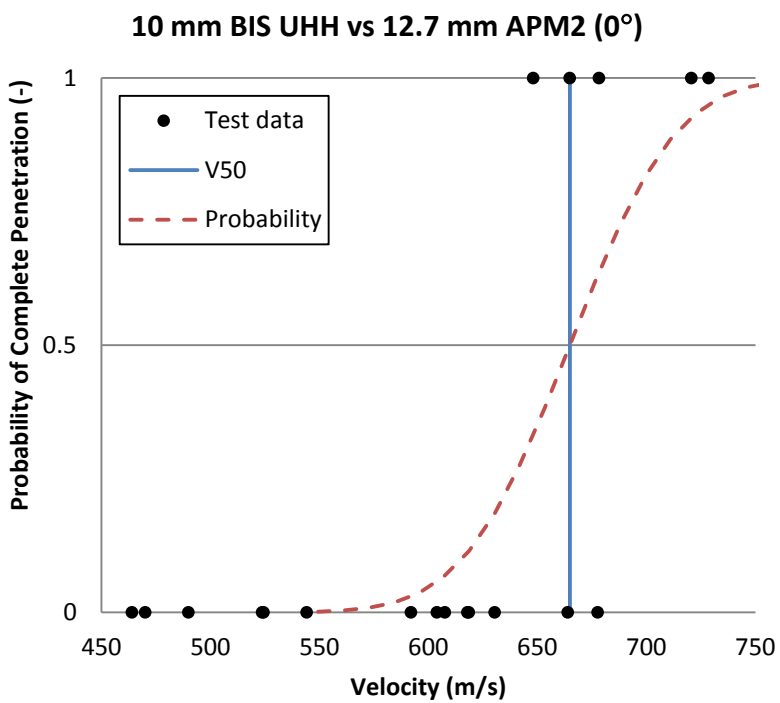
- Testing performed by DST and ARL
- V_{50} assessed as per MIL-STD-662F & MIL-DTL-32332

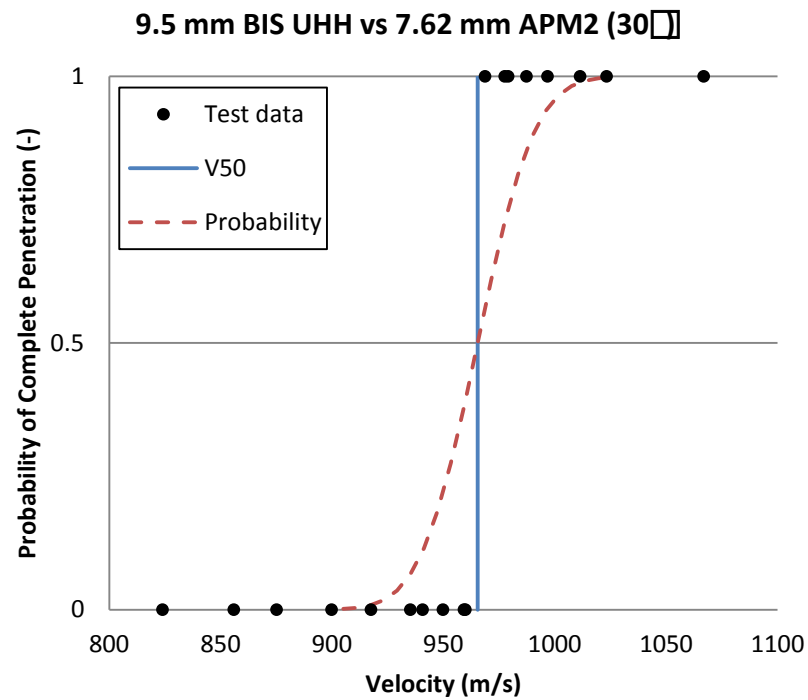
No.	Thickness:	Projectile:	Obliquity:	V_{50} (m/s):	σ (m/s):
1	9.8 mm	7.62mm APM2	0°	865	25
2	9.8 mm	7.62mm APM2	30°	965	20
3	7.4 mm	7.62mm APM2	30°	910	14
4	10.2 mm	12.7mm APM2	0°	665	39
5	12.2 mm	12.7mm APM2	0°	686	22
6	12.2 mm	12.7mm APM2	30°	796	29
7	11.5 mm	12.7mm APM2	30°	795	11
8	10.41 mm	12.7 mm FSP	0°	726.9	19.7
9	12.16 mm	12.7 mm FSP	0°	831.5	13.4

Target photos

AP testing

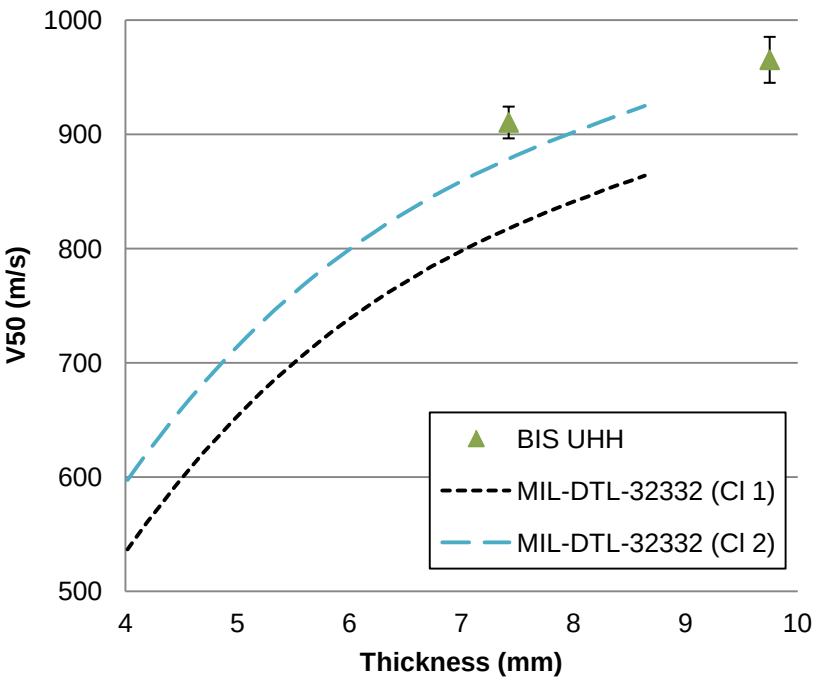
- Only <u>one</u> projectile core recovered intact (of 132 tests)
  - Tests performed ~ 300 m/s below V_{50} with 7.62 mm APM2
  - Tests performed ~200 m/s below V_{50} with 12.7 mm APM2
- Even at normal incidence, no shatter gap observed

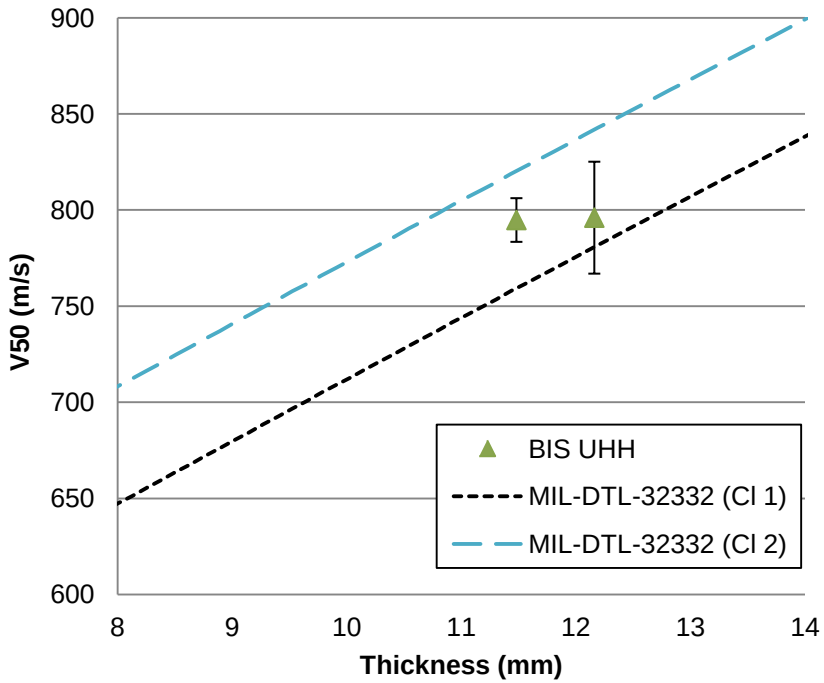




MIL-DTL-32332 Performance

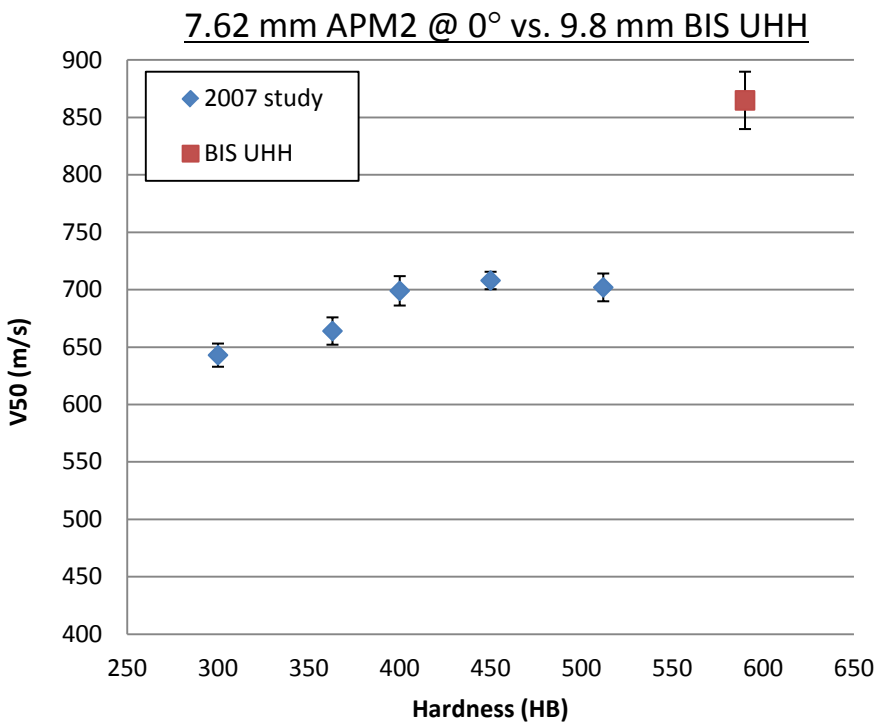
- Meets Class 2 requirement against 7.62 mm APM2
- Meets Class 1 requirement against 12.7 mm APM2
- No performance requirement for FSP

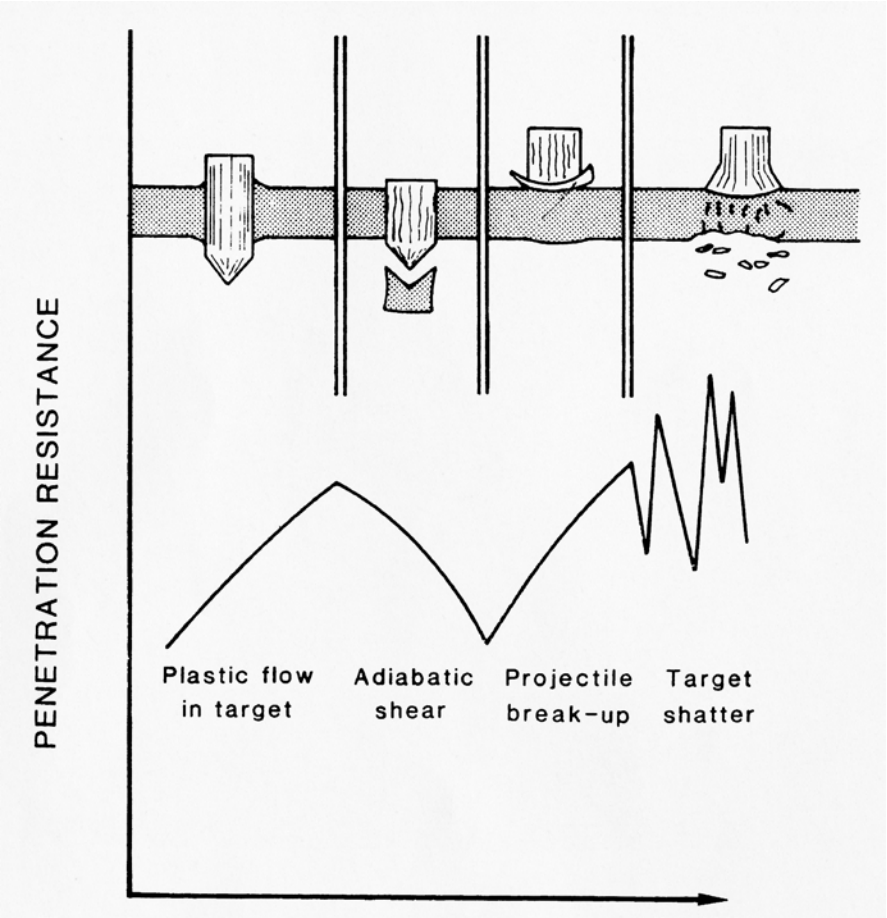




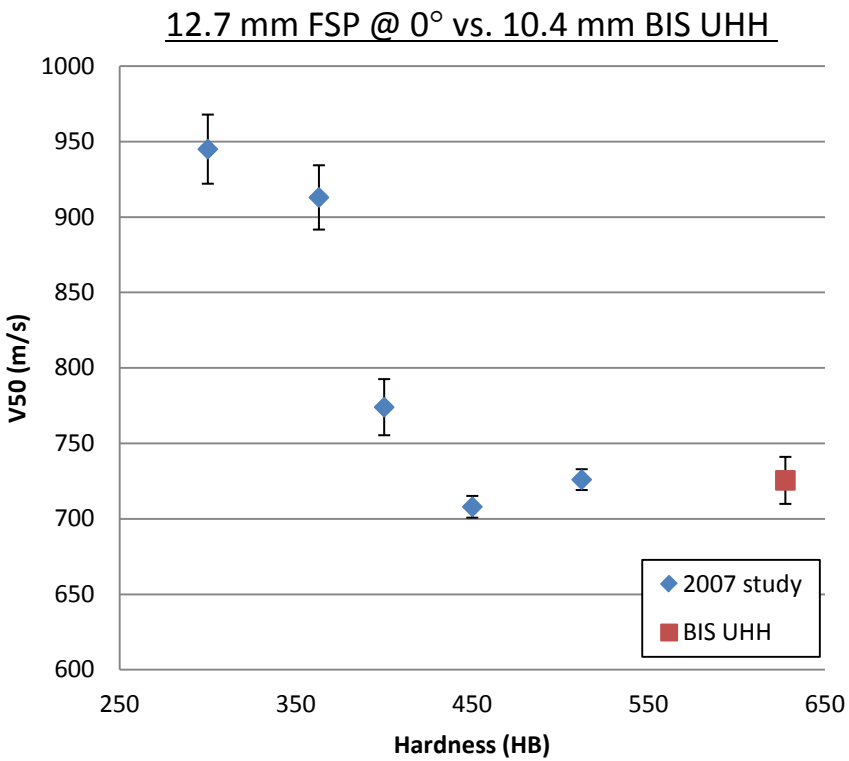
Revisiting the ARL/DSTO Bisalloy study

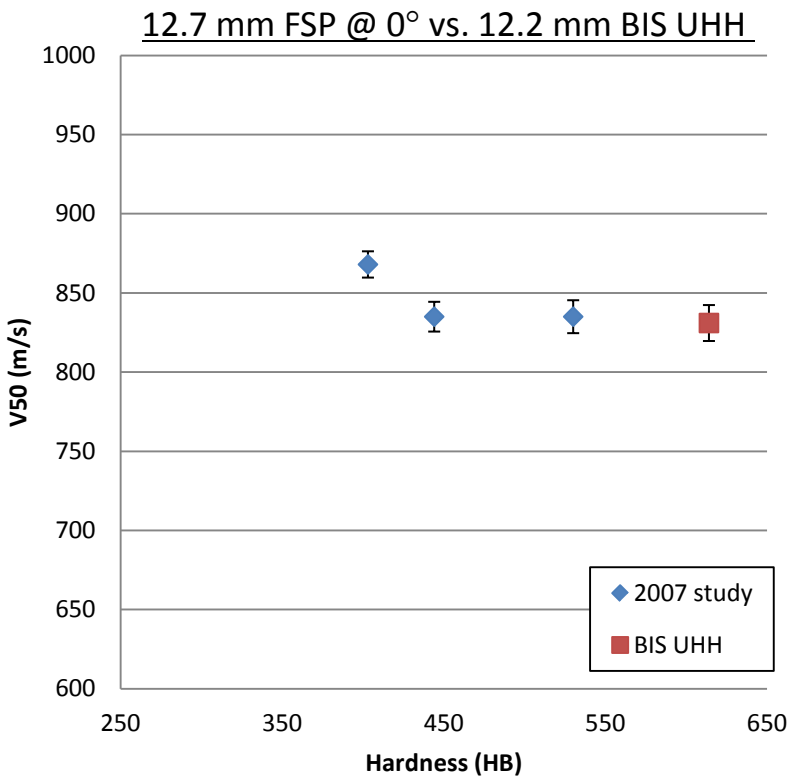
- Testing on a range of Bislloy plates (2007 ISB):
  - From BIS80A, 235-293 HB (<MIL-A-12560H Class 2)
  - To BIS HHA, 477-534 HB (MIL-A-



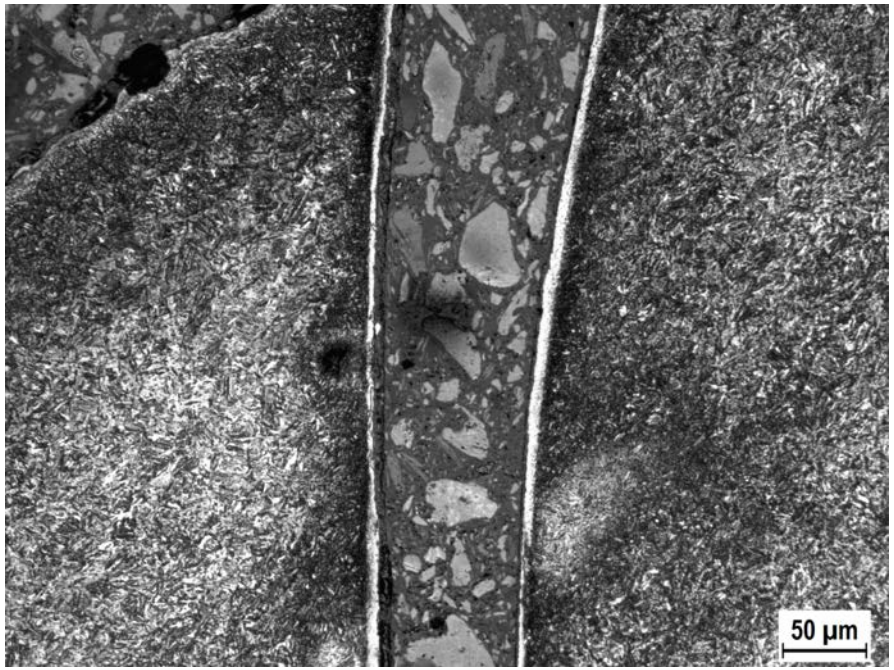


Revisiting the ARL/DSTO Bisalloy study (cont.)



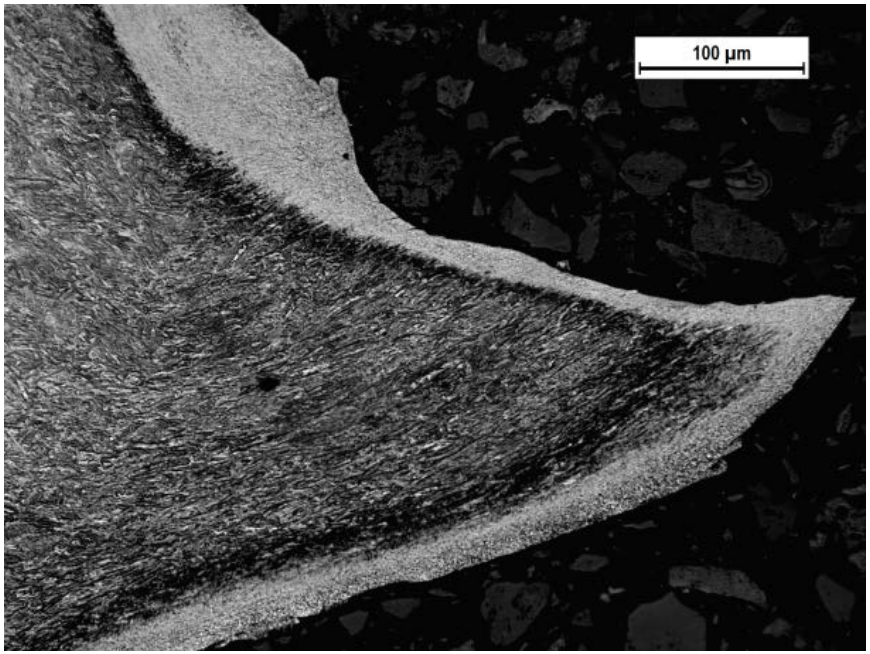


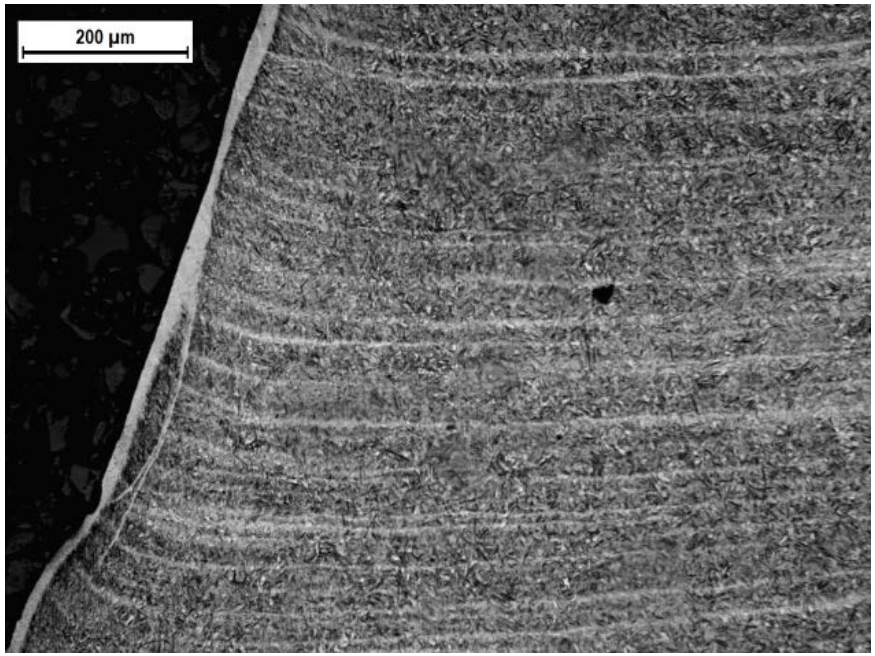
Microscopy Evaluation



- Examples of ASB formation in the BIS UHH plate
- ASBs resist etching → appear as white bands in the above
- Hardness traverse also revealed increased hardness in ASB, lower values in the ASB-steel matrix interface

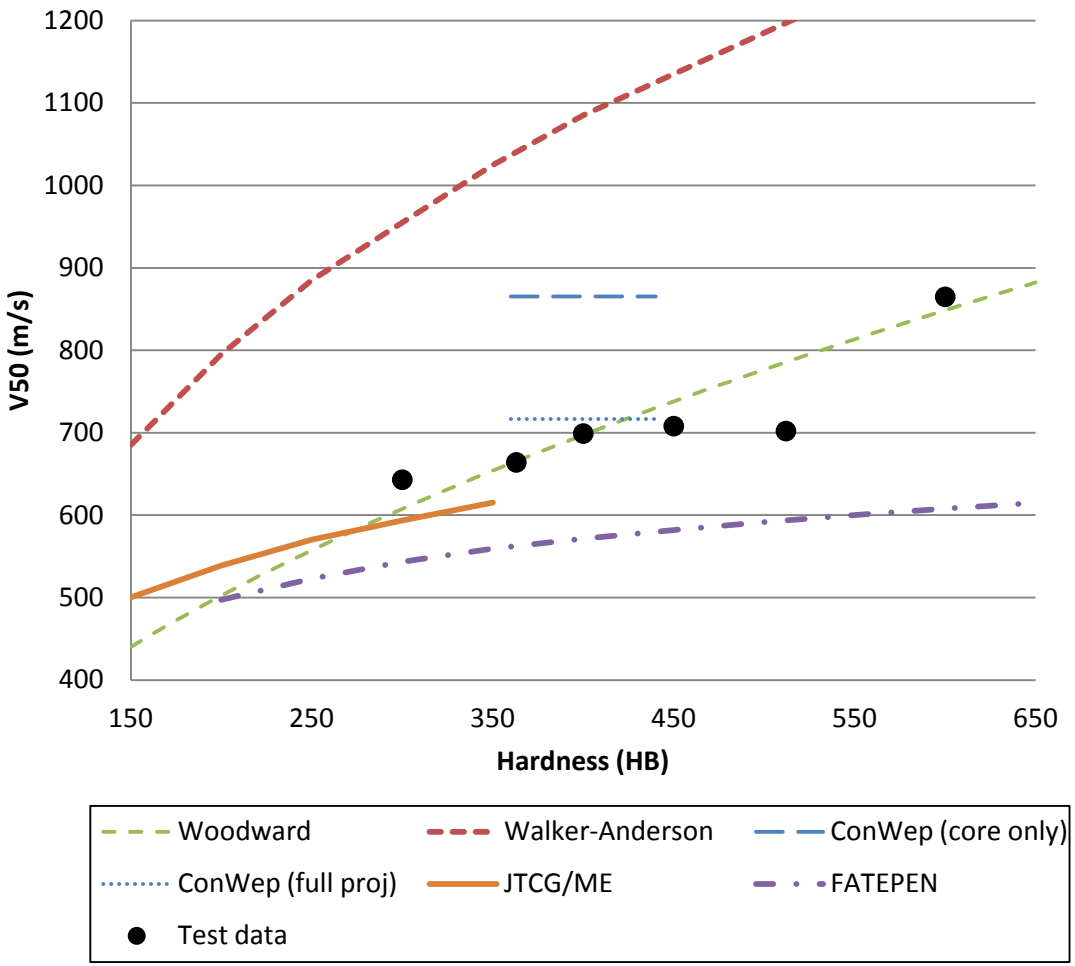
Microscopy Evaluation (cont.)





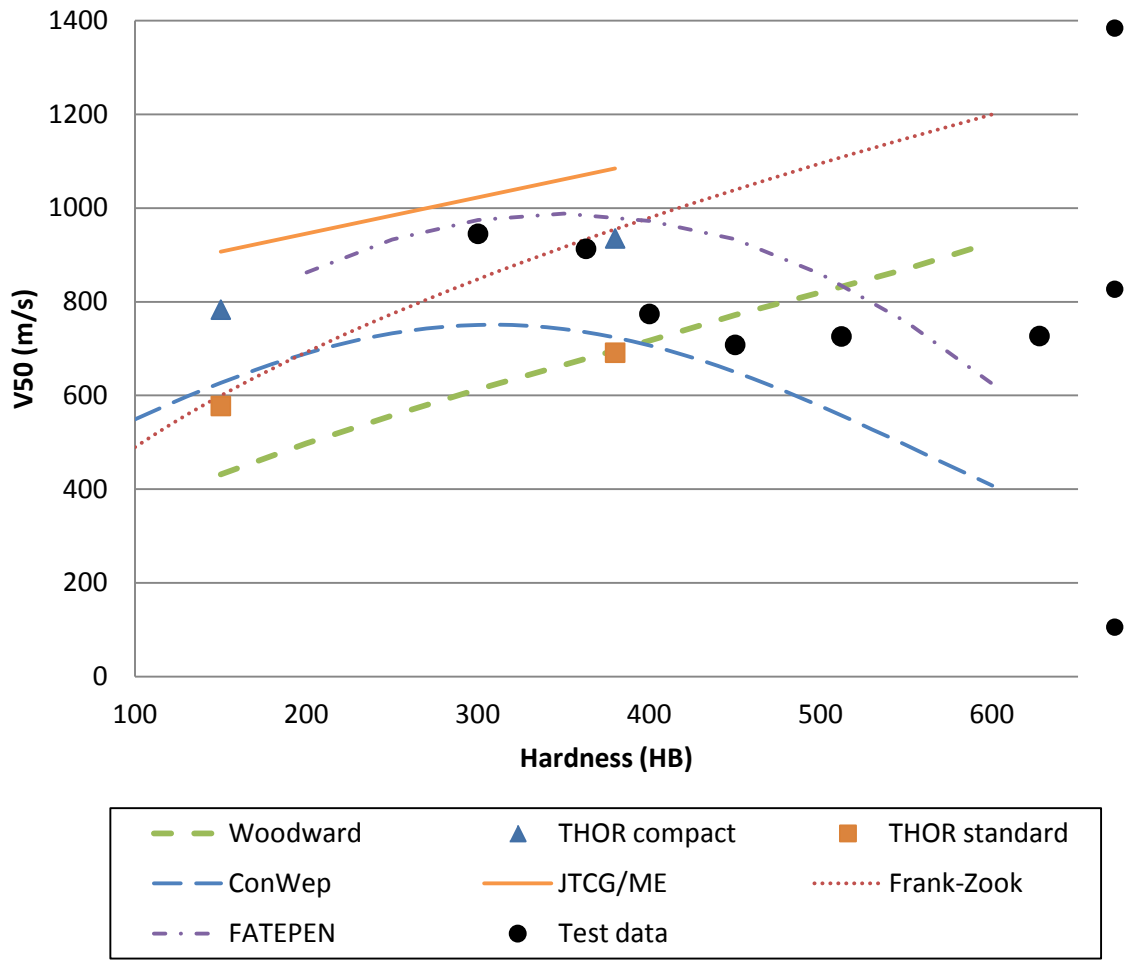
- Examples of ASB formation in ejected plugs

Application of Predictive Models – AP



- Qualitative evaluation of trend
- Not a 'fair' application of some (will affect quantitative accuracy)
- No models able to predict ASB-related performance plateau

Application of Predictive Models – FSP



- Qualitative evaluation of trend
- Again, not a 'fair' application of some models
- FATEPEN and ConWep show best agreement

Summary and Conclusions

- Ballistic performance of Bislloy UHH (~600 HB) experimentally evaluated
- Performance mapped over hardness range of ~300-600 HB for both FSP and AP type projectiles
- Complex phenomenology not well reproduced by empirical/analytical methods