What do we know about the Cheonan?

J.J. Suh

SAIS

Johns Hopkins University

The Cheonan Before and After

Outline

- What the JIG argues
- Underwater explosion outside the Cheonan
  - Fragments
  - Shock wave
  - Bubble effect
- So what do we know?

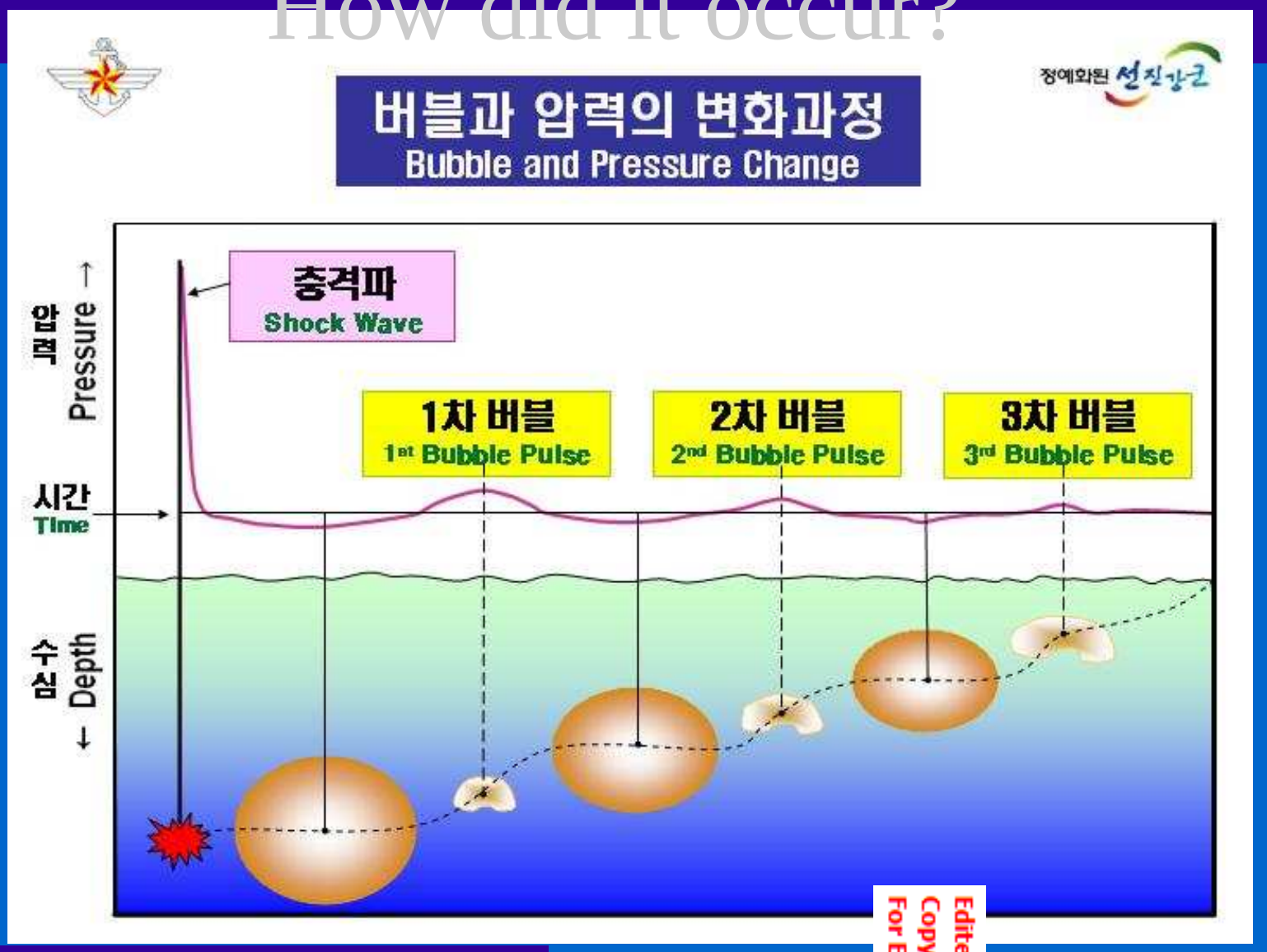
The JIG's Argument

- The JIG argues
  - An outside explosion severed the Cheonan
  - A torpedo caused the outside explosion
  - It was a North Korean torpedo
  - Therefore, a North Korean torpedo destroyed the Cheonan

Underwater Explosion

- Underwater Explosion Produces
  - Fragments
  - Shockwave
  - Bubble Effect
  - Water column

How did it occur?



Where are Fragments?

- Not here

Where are Fragments?

- Not here either

What about shock wave?

$$P_0 = 52.4 \cdot (W^{1/3} / R)^{1.18}$$

P=pressure in MPa
W=weight of TNT in kg
R=stand-off in meters

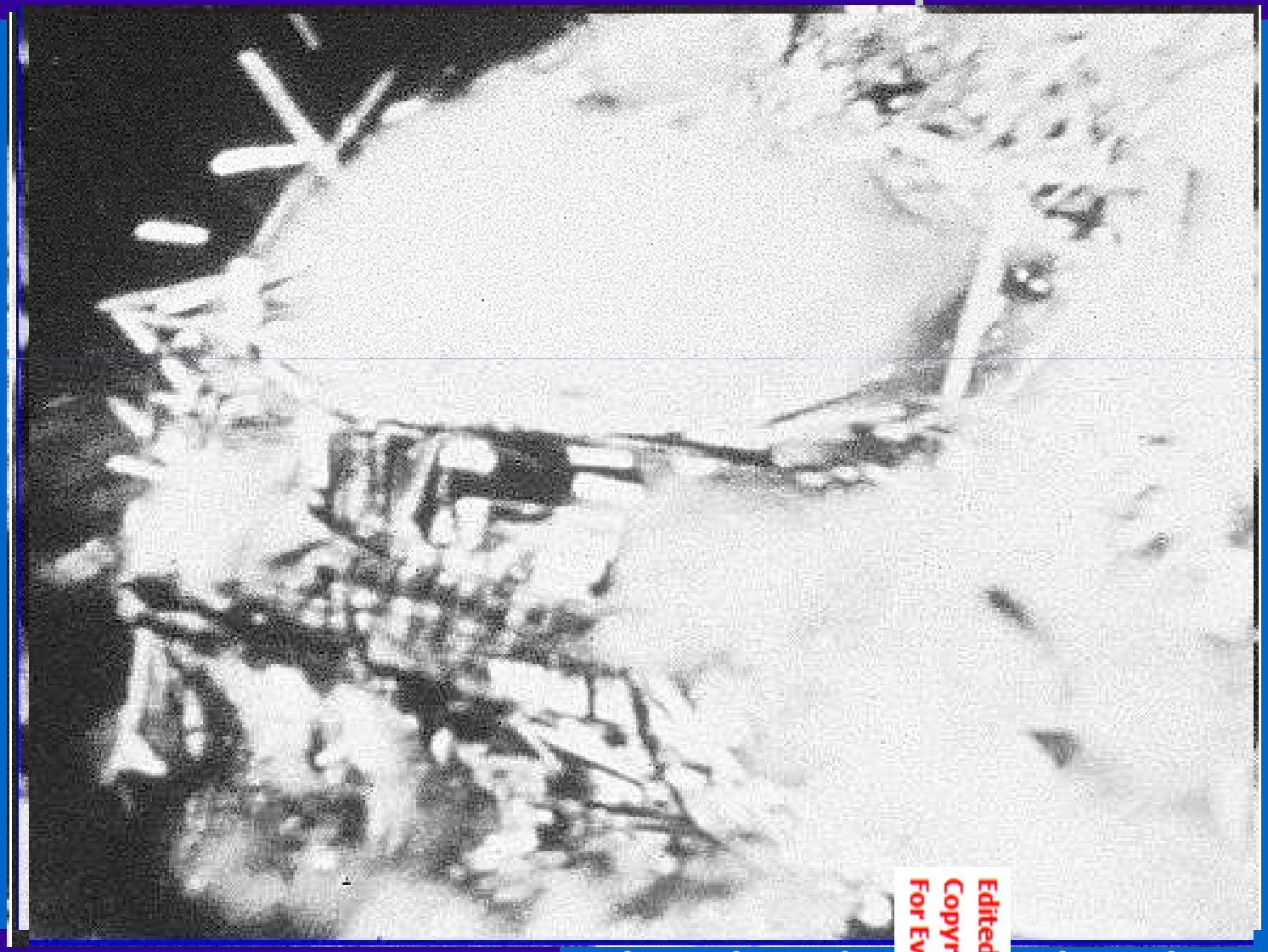
Published by

DSTO Aeronautical and Maritime Research Laboratory
PO Box 4331
Melbourne Victoria 3001

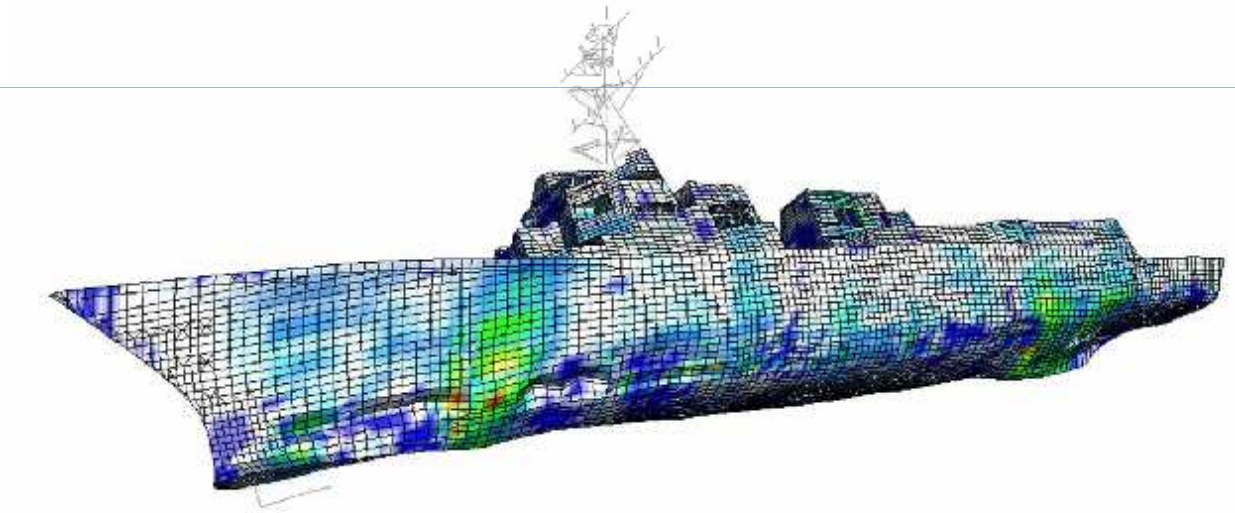
W=250 kg of TNT
R=3~6 meters

→P=8,049~18,239 psi

Shock Wave at 5psi



Prediction of Potential Damage



Shock Wave on the Cheonan?

Secondary Effect of Shock Waye?

40mm 탄약고

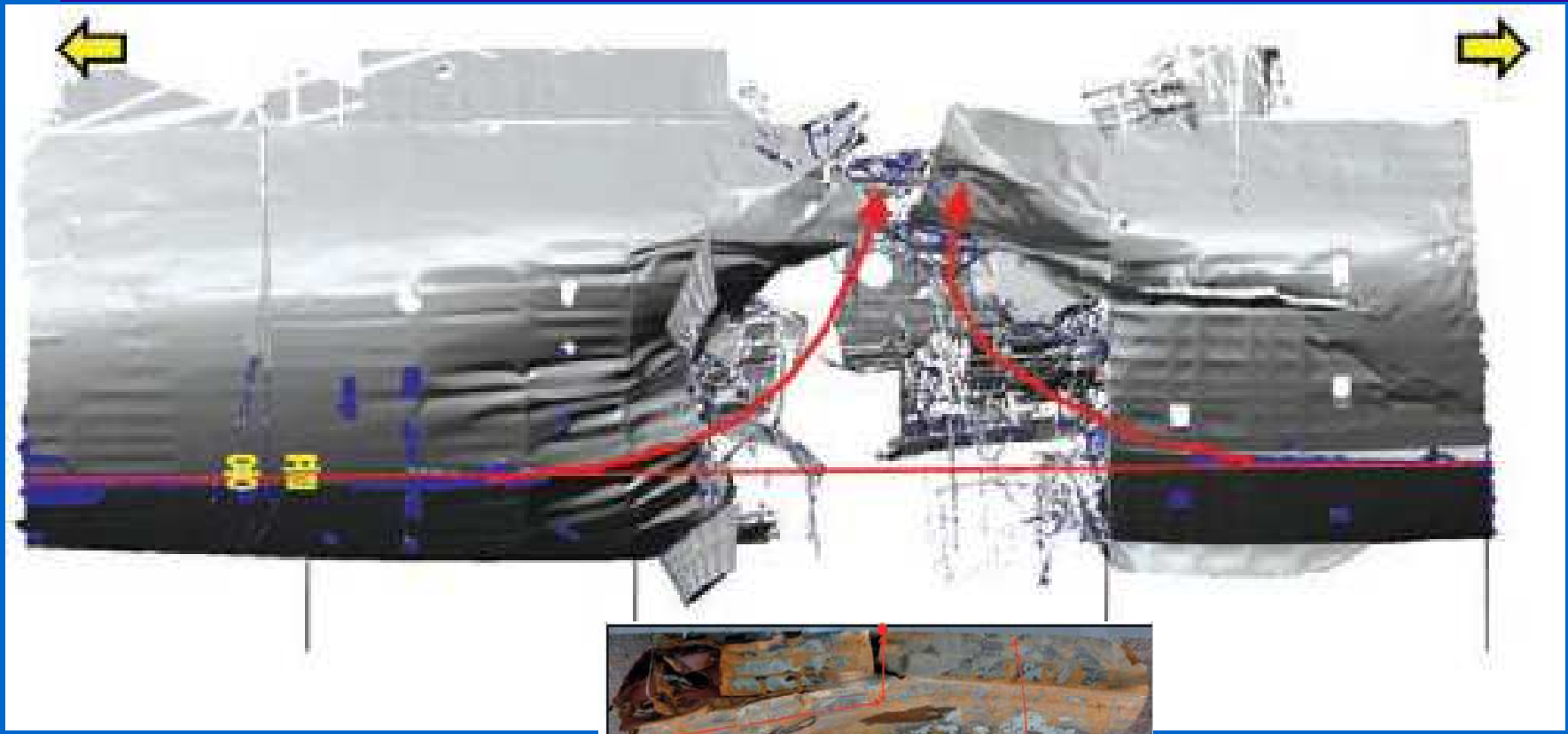
Shock-proof Light Bulbs?

Bubble Process (1/3)

Bubble Process (2/3)

Bubble Process (3/3)

Three Parts Break-up



The Report's Bubble Effect

정예화된 선진강군

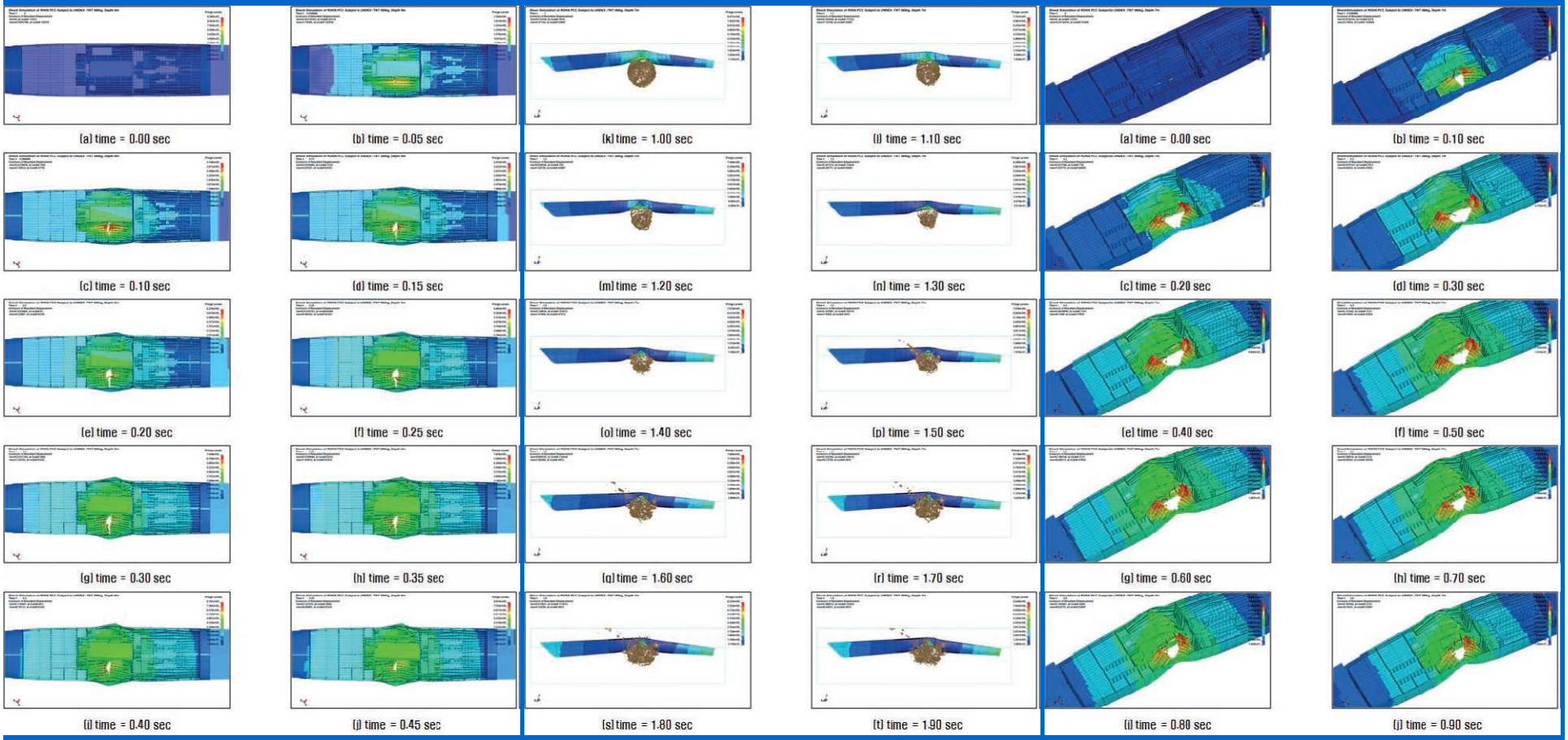
시뮬레이션 결과
Simulation Result

가스터빈실 좌현 3m, 수심 6~9m에서
고성능 폭약 250kg 규모가 폭발시, 천안함 변형현상과 유사

Explosion of about 250kg high explosive at 6~9m in water depth and at 3m to port from center line of gas turbine room results in similar deformation as seen on ROKS Cheonan

Bubble Effect on the Cheonan?

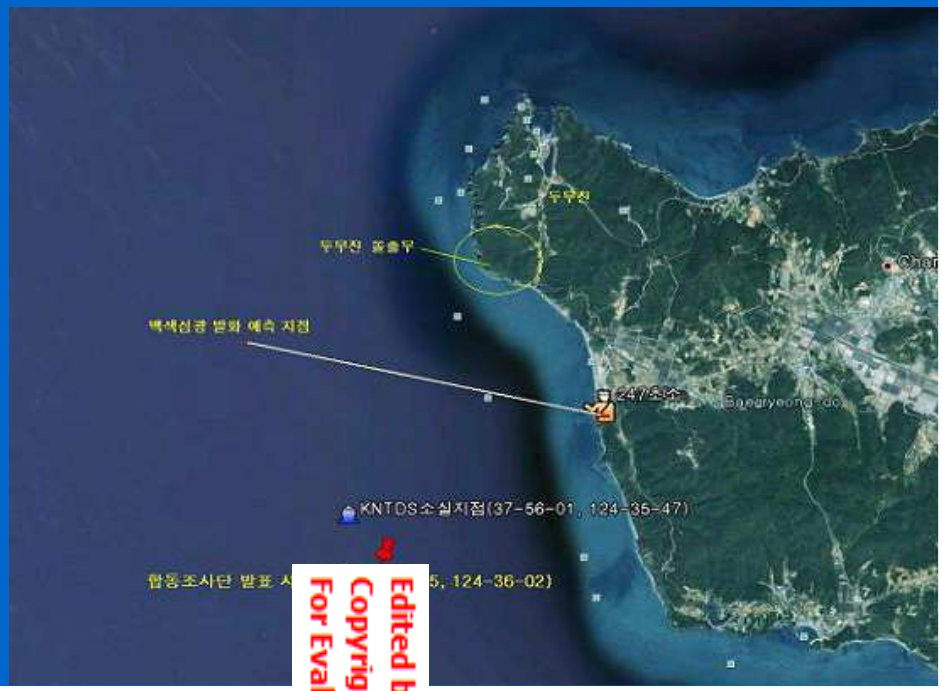
Bubble Doesn’t Cut It



What about Water Column?

Sailor on the Deck:
“felt a sprinkle of water on the face”

Patrols on Baekryong Island: “a flash of light”



So …

- No sign of the shock wave
- No sign of the bubble effect
- No fragments
- No evidence of water column

→ Was there really the “outside explosion”?

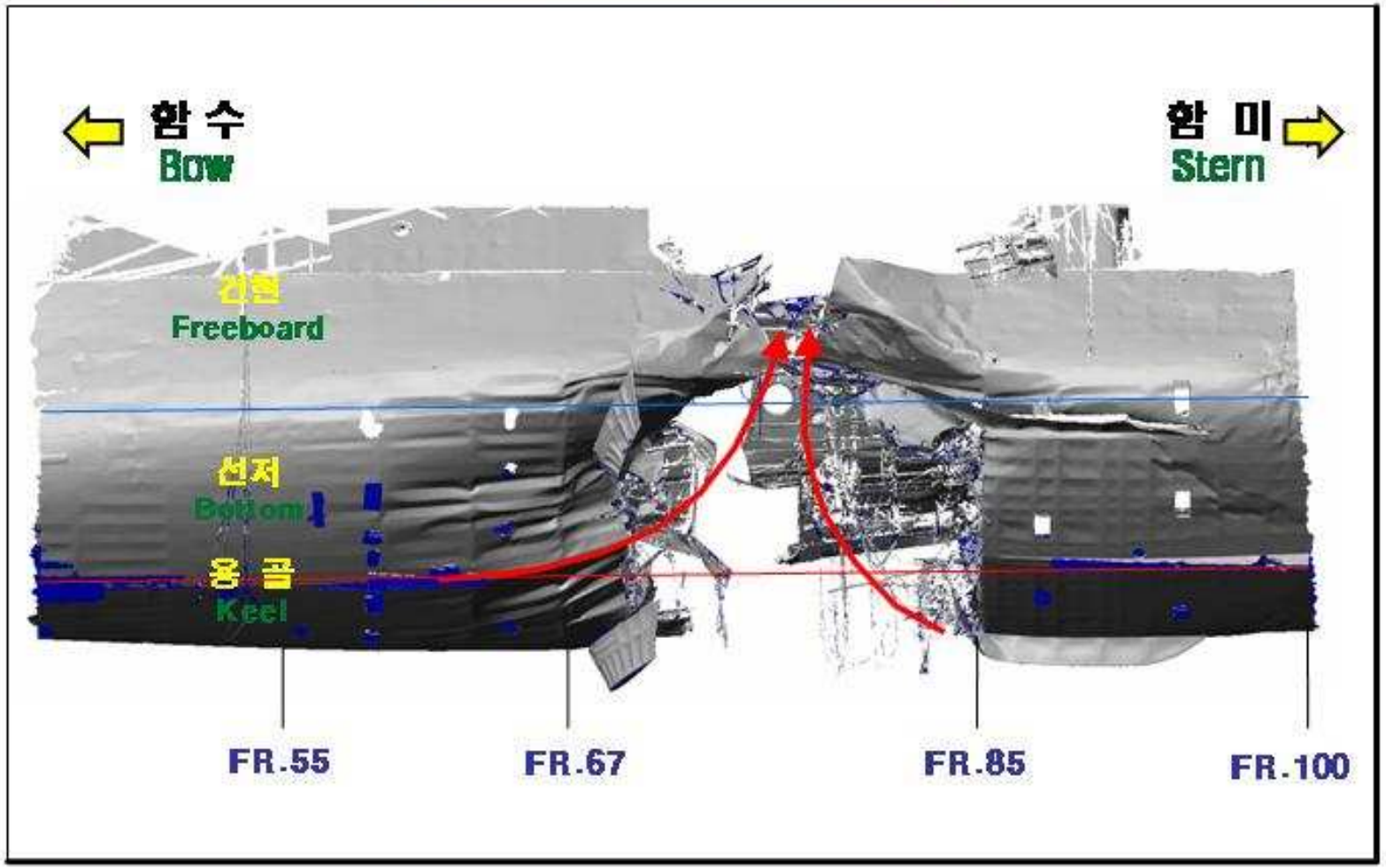
So…

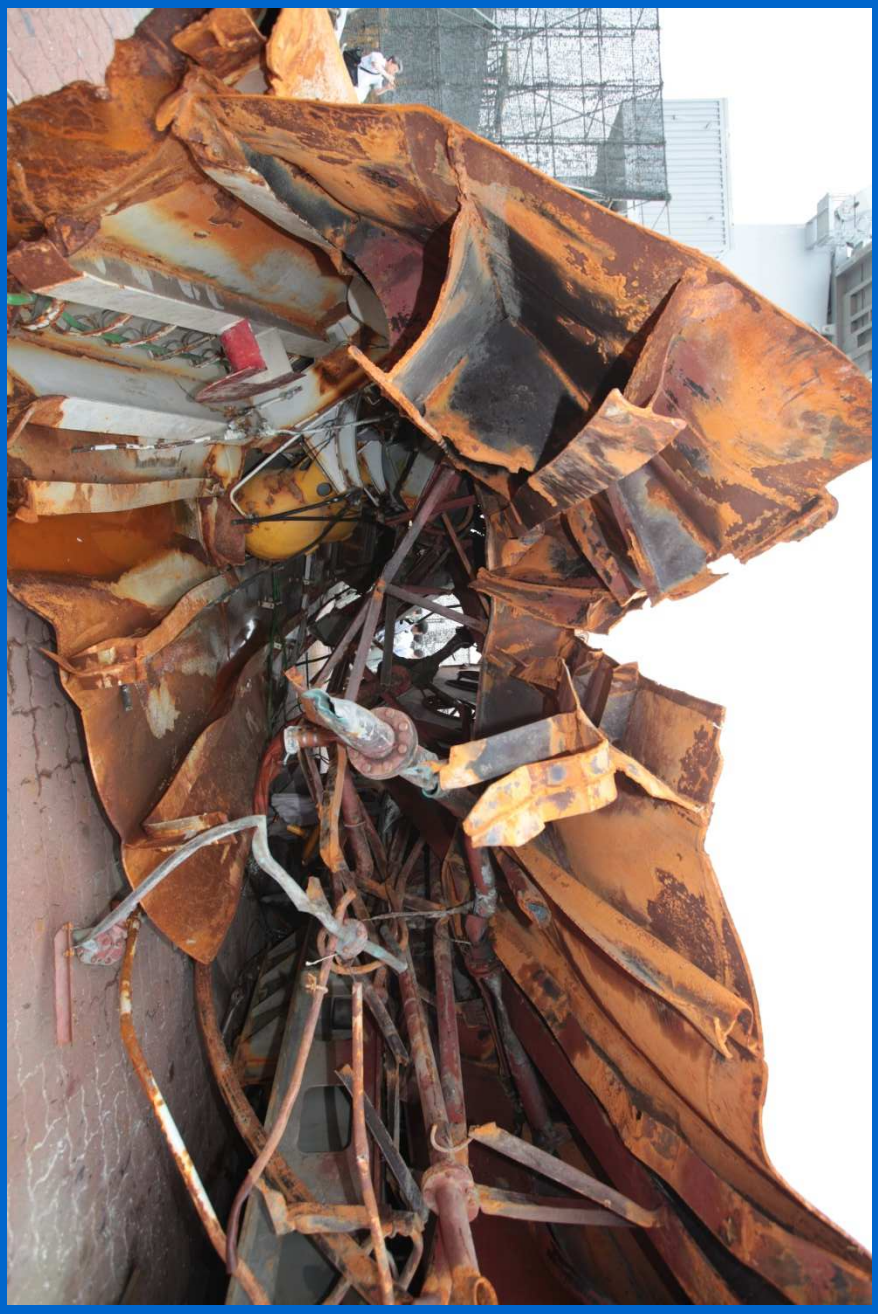
- The JIG argues
  - An outside explosion severed the Cheonan
  - A torpedo caused the outside explosion
  - It was a North Korean torpedo
  - Therefore, a North Korean torpedo destroyed the Cheonan

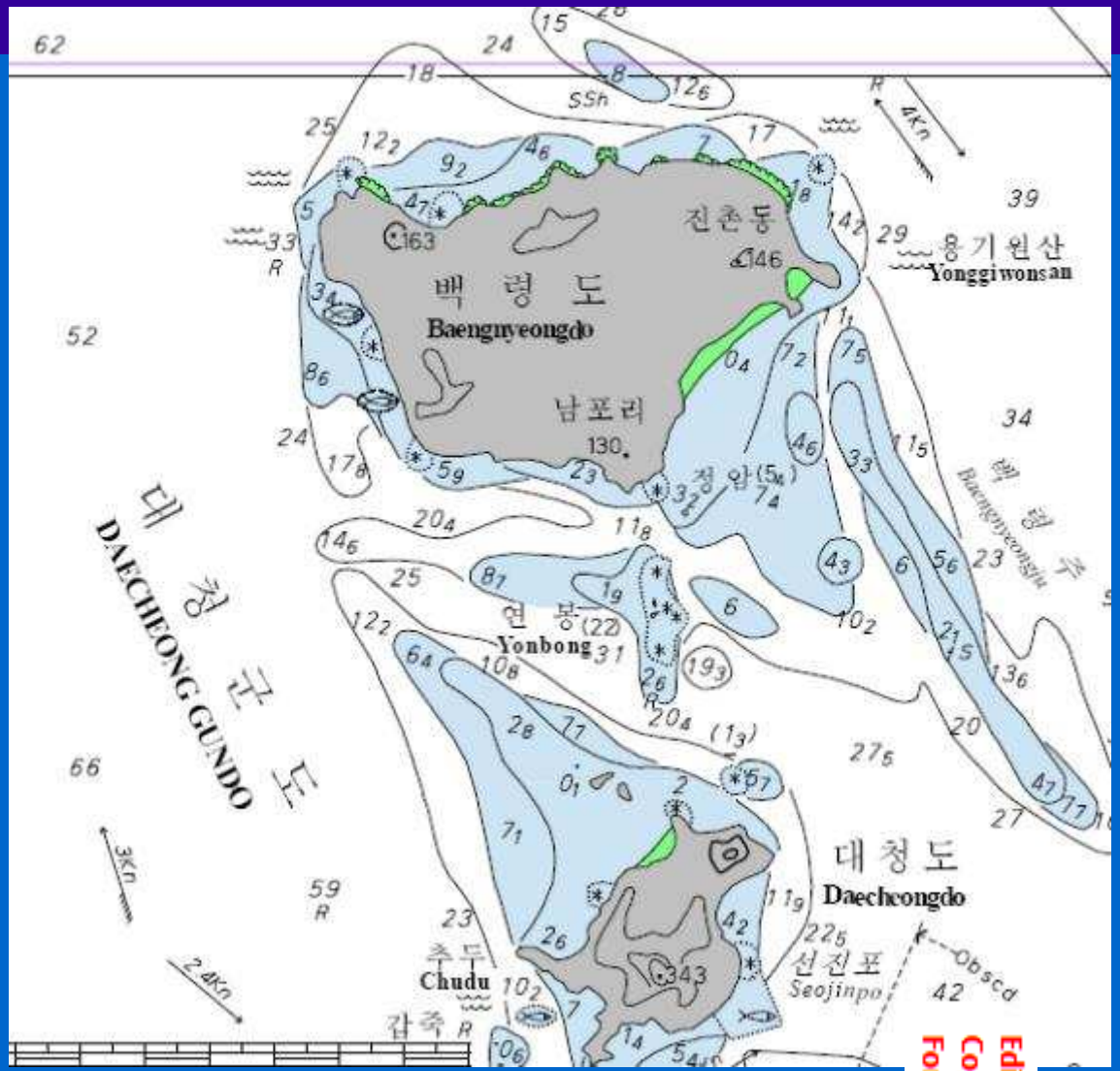
Q & A

절 단 부 위 (좌현)
Portside View

정예화된 선진강군







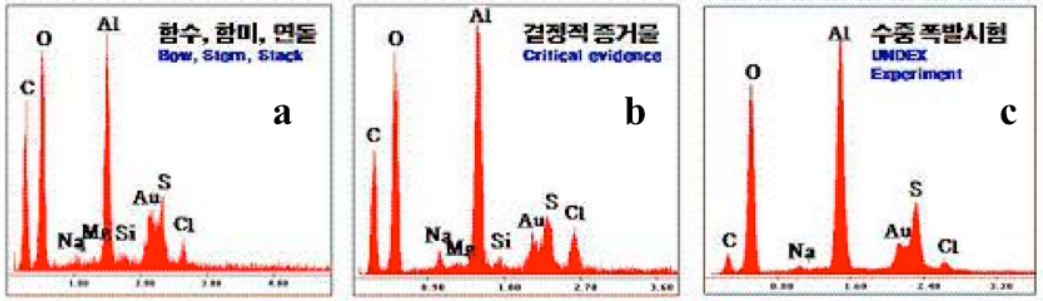
“Critical Evidence”

Did a NK torpedo sink the Cheonan Ship ?

What does the evidence tell us..

Seung-Hun Lee
Department of Physics, University of Virginia

- The ROK (South Korea) JIG's claim
  - on May 15, 2010, "recovery of the conclusive evidence" that are fragments of a torpedo
  - the following two "scientific" evidence -> explosion of the NK torpedo sank the Cheoan
    1. The "No. 1" blue ink mark in Korean on the propulsion part of the torpedo
    2. The Energy Dispersive Spectroscopy (EDS) and x-ray Diffraction (XRD) of three adhered materials



〈에너지 분광기 분석 결과〉 EDS Analysis result

- Our scientific examination/experiment: the "No. 1" torpedo is a fabrication.

Two Evidence for Two Key Links in the Cheonan report

Both links must hold in order for the JIG's conclusion to be correct.

North Korean Torpedo

↓ The blue korean mark "No 1"

▲ ⓒ뉴시스

Explosion of the Torpedo

↓ The EDS and x-ray data of three "adhered materials"

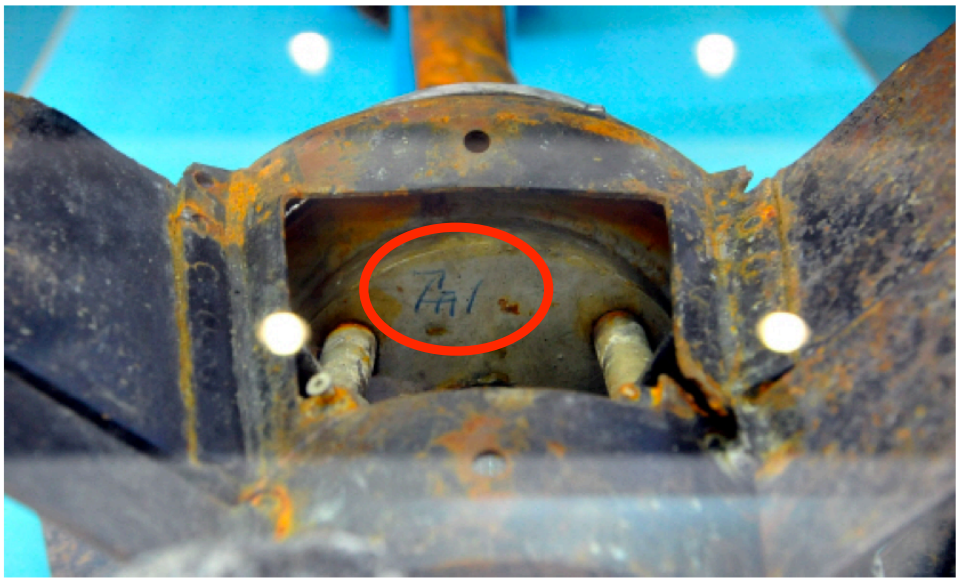
▲ 흡착물을 채취한 선체 및 어뢰 프로펠러의 부분과 흡착물 가루(오른쪽) ⓒ민군 합동조사단

▲ 합조단이 실시한 수중폭발실험과 거기서 나온 흡착물 가루 ⓒ민군 합동조사단

Sinking of Cheonan

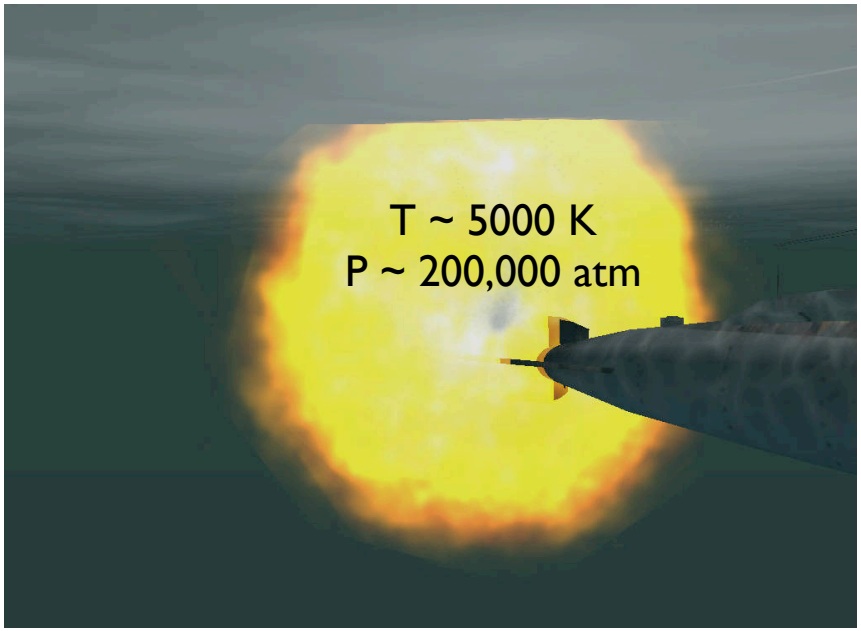
I. The "No. 1" mark

The recovered(?) torpedo



▲ ©뉴시스

http://img316.imageshack.us/i/torpexplosion18cq.jpg/



- This cannot even be an "evidence":
  any Korean, North and South, can write this mark.

- Also, it does not make sense that the ink mark can survive unscratched when the paint was all burned at the explosion.
  - A youtube video that shows burning of monami "1 beon" mark by a torch: http://www.youtube.com/watch?v=EROwzmPgmsM

- Even circumstantially, it does not make sense at all.
(1) Who on earth would write such a coarse mark on such an expensive warhead?
(2) The mark was well deep inside the torpedo and it could not be seen from outside once the torpedo was completely assembled. What would have been the purpose of the mark?
(3) Why weren't there any other marks on other parts?

The Chosun Ilbo
english.chosun.com

Jun. 30, 2010 11:05 KST

Cheonan Investigators Presented Wrong Torpedo Diagram

Regarding the numbering "1 beon" written on one of the torpedo's pieces, the investigative team said analysis of the ink confirmed that it was an oil-based magic marker made using the ingredient Solvent Blue 5, and it is trying to secure samples for comparison. The team said Solvent Blue 5 is commonly used in magic markers, which North Korea may have imported, but the marker cannot be traced to the North with certainty.

THE HANKYOREH

July 5, 2010

Questions linger 100 days after the Cheonan sinking

Second, the team announced during a June 29 briefing for press groups, including the Journalists Association of Korea and the National Union of Mediaworkers, that its analysis results showed ingredients of "Solvent Blue 5" in the blue oil magic ink used to write "No. 1" on the torpedo's propeller. However, the solvent line is a commonly used ingredient in ink, and since the team was unable to secure a sample of North Korean ink to compare it with the ingredients in the ink used to write "No. 1," it is insufficient as evidence.

Two Evidence for Two Key Links in the Cheonan report

Both links must hold in order for the JIG's conclusion to be correct.

North Korean Torpedo

The blue korean mark "No 1"

▲ ©뉴시스

Explosion of the Torpedo

The EDS and x-ray data of three "adsorbed materials"

▲ 흡착물을 채취한 선체 및 어뢰 프로펠러의 부분과 흡착물 가루(오른쪽) ©민군 합동조사단

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Sinking of Cheonan

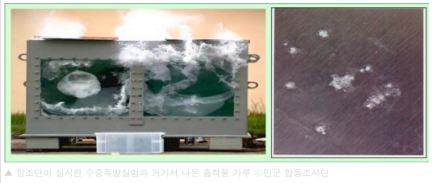
iPhone made in North Korea !!!

II. Adhered Materials

AM-I

AM-II

AM-III

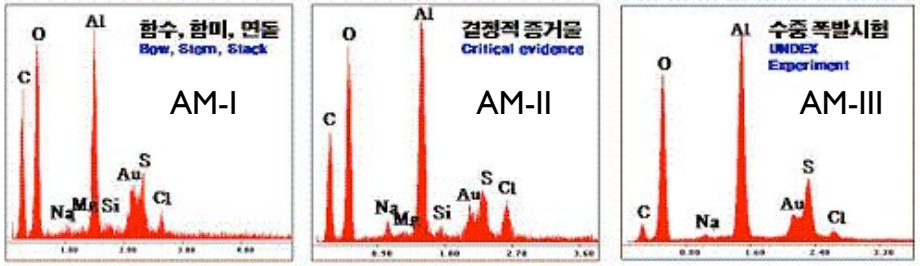


EDS : probes the ingredient atoms of a sample

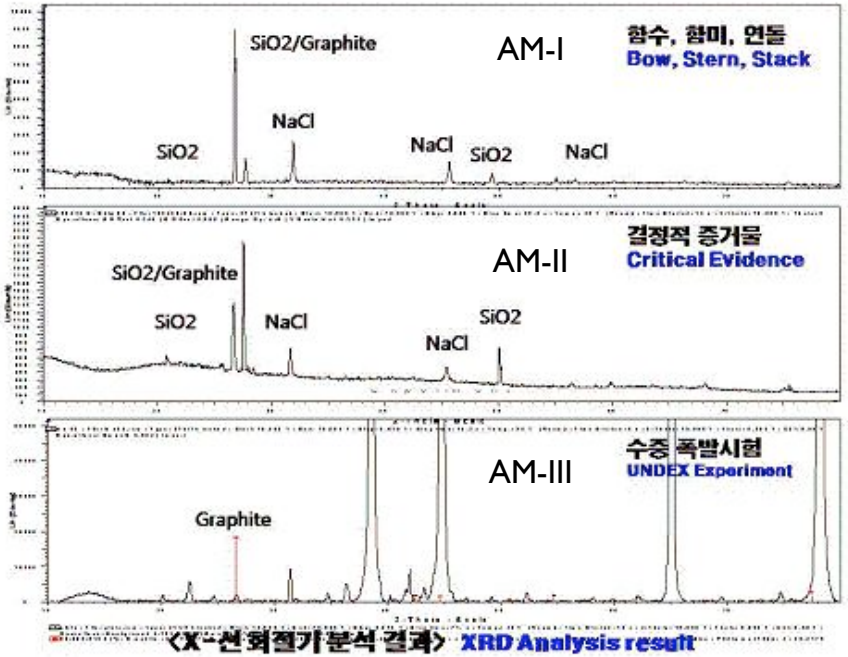
XRD : probes the chemical compounds that the atoms form

성분 분석 결과
Substance Analysis Result

검출 물질 Extracted	함량(%) Content	비고 Notes	검출 물질 Extracted	함량(%) Content	비고 Notes
알루미늄 산화물(Al_xO_y)	45~55	비결정 Amorphous	황 Sulfur	3.5~4.5	
탄소(C)	0.6~3.0	일부 흑연 Graphite	수분 등 Moisture etc.	36~42	



〈에너지분광기 분석 결과〉 EDS Analysis result



〈X-선 회절기분석 결과〉 XRD Analysis result

- JIG argues the strong Al and O signals in all three samples are due to oxidized aluminum, Al_2O_3 formed by the explosion

- NOTE THAT the Al and O intensity ratio, I(O)/I(Al) ~ 0.9, for all samples

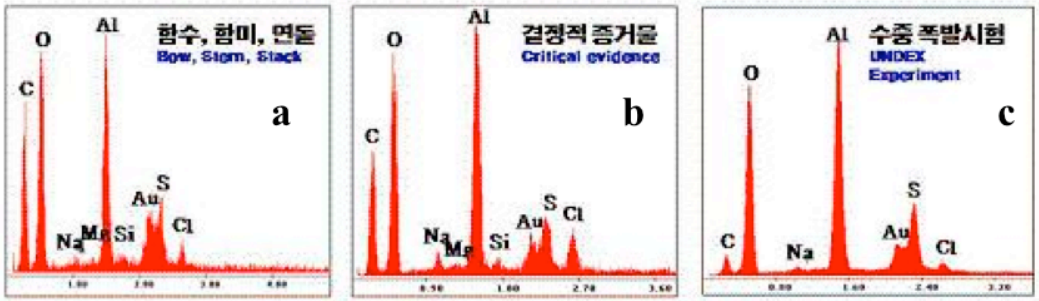
- AM-I and AM-II data: *no significant Al-related signals*, later found a negligible signal for crystalline Al_2O_3
- JIG claims that the absence of the Al_2O_3 signals indicates that all Al_2O_3 are amorphous and it cannot be detected by x-ray.

- NOTE THAT the AM-III XRD data exhibit strong *crystalline* Al peaks and weak Al_2O_3 peaks

Are the adhered materials Al_2O_3 (explosion) or $Al(OH)_3$ (Corrosion)?

JIG's EDS data, in the Final report pages 154 and 278

Ship Torpedo Test explosion

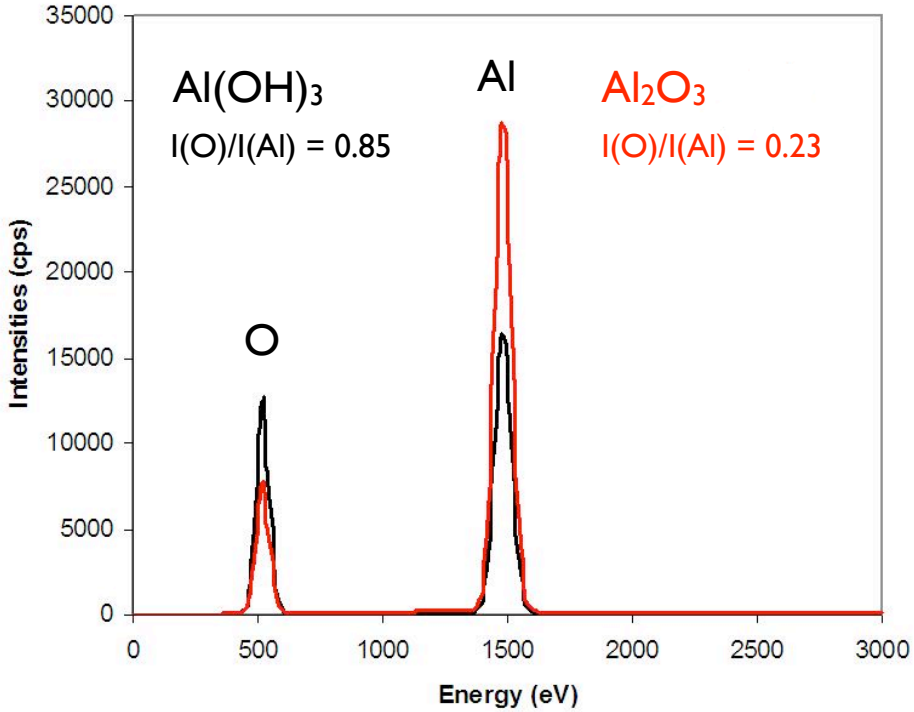


〈에너지 분광기 분석 결과〉 EDS Analysis result

- I(O)/I(Al) ~ 0.9 for all samples

EDS simulation by Dr. P. Yang (University of Manitoba, Canada)

Lee & Yang, arXiv1006.0680
http://arxiv.org/abs/1006.0680



- **Us:** I(O)/I(Al) = 0.23 for aluminum oxide, Al_2O_3. Why their ratio is ~ 0.9?
- **JIG** on June 29: all three samples contained ~ 40 % moisture
- **Us:** EDS measurements are done UNDER VACUUM. So NO moisture can exist during the EDS measurements

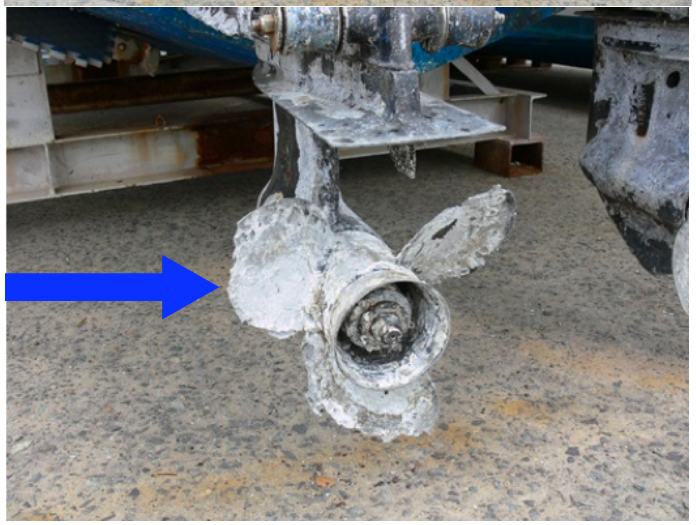
- I(O)/I(Al) = 0.85 for aluminum hydroxide, $Al(OH)_3$
- It can be naturally formed when Al is exposed to water

- The adhered materials extracted from the ship and torpedo are not associated with any explosion

The "No. 1" Torpedo

A boat that survived a torpedo explosion?

Al alloy



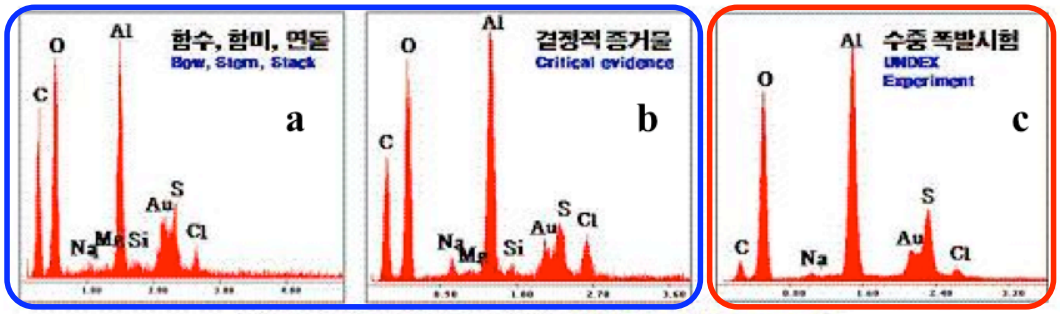
Effect of corrosion of Al alloy: formation of white powder ($Al(OH)_3$)

Most likely, a fabrication...

$Al(OH)_3$ (Corrosion) Al_2O_3 (explosion)

Ship Torpedo Test explosion

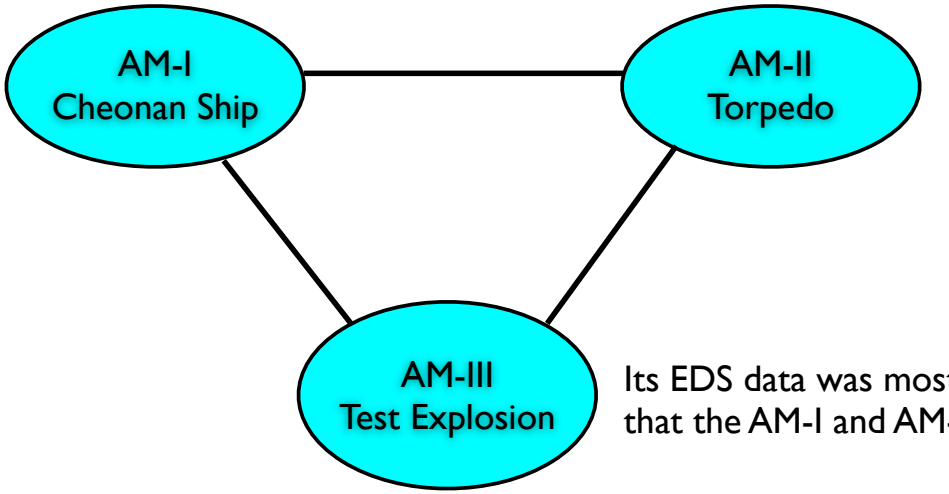
EDS data



〈에너지 분광기 분석 결과〉 EDS Analysis result

- I(O)/I(Al) ~ 0.9 for all samples

- Why I(O)/I(Al) ~ 0.9 for the AM-III?
- Since the AM-III came from the test explosion, Al_2O_3 should be detected by EDS to yield I(O)/I(Al) ~ 0.23.



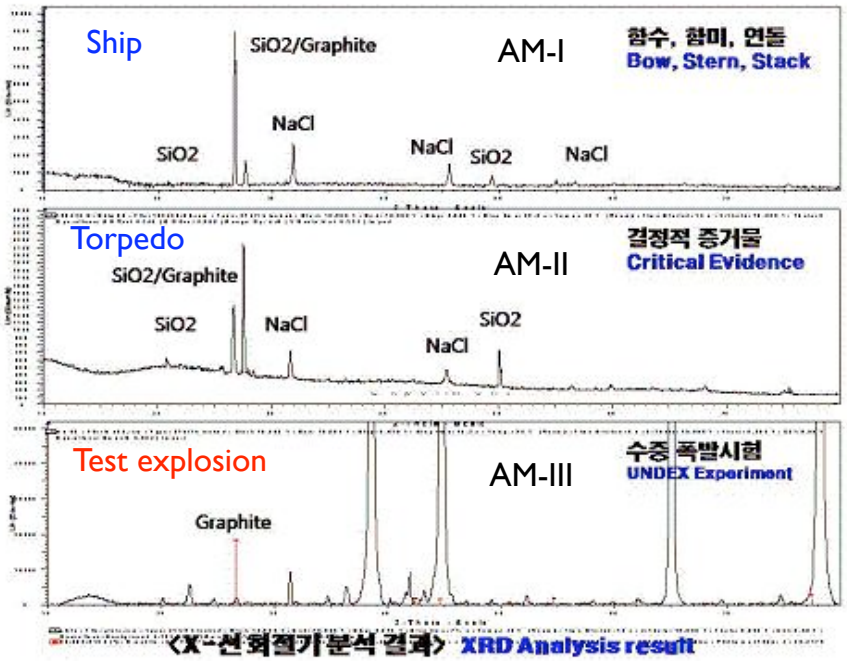
Its EDS data was most likely fabricated to claim that the AM-I and AM-II are explosive-related materials

We demanded the JIG to release all three samples, and the JIG released the samples from ship and torpedo, but they refused to release the sample from the test explosion.

In their Final Report, the JIG still insists that the white powder samples are Al_2O_3 (explosion)

JIG's EDS analysis results

Compounds	Oxidized Al	C	S	SiO_2 (AM-I, II)	Moisture etc
Weight %	45 ~ 55	0.6 ~ 3.0	3.5 ~ 4.5	~ 2.9	36 ~ 42



- **Us:** Where is XRD signal of oxidized aluminum?

- **JIG** claim: The absence of the XRD signal indicates that Al_2O_3 is 100% amorphous.

- **Us:** that is not true. See AM-III (test explosion). There are strong crystalline Al peaks. This means that not all Al got oxidized during the explosion and some of it remains crystalline. This was consistent with our own experiment of melting and quenching of Al. Furthermore, our own experiment suggested that during explosion crystalline Al_2O_3 should be also produced.

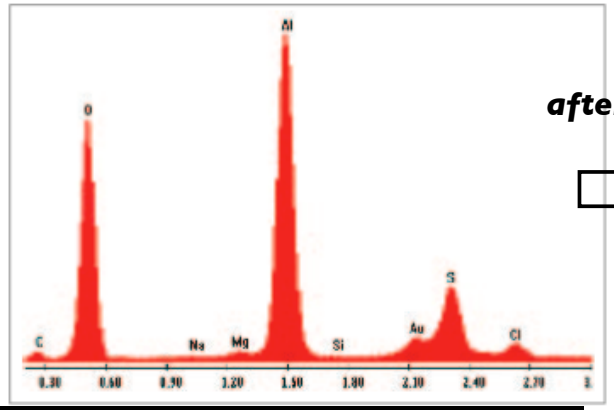
- **JIG**: provided no scientifically reasonable argument. Instead, in their final report they removed all EDS and XRD data of the test explosion sample out of the main text and put them in the Appendix.

The JIG's new experiments of heat treatment on the adhered materials from ship and torpedo

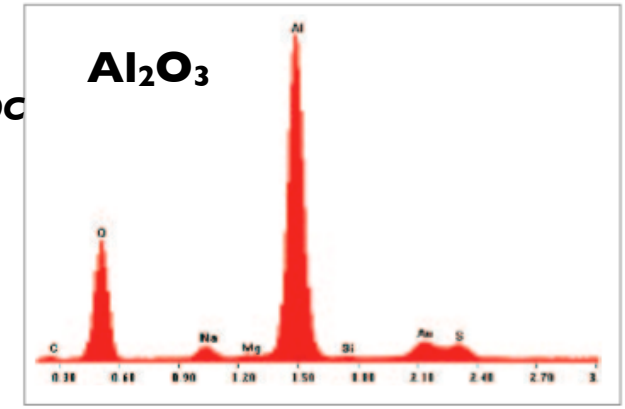
In the JIG's Final Report Appendix Pages 280-288, released on September 13, 2010

The adhered material ***before the heating***

EDS



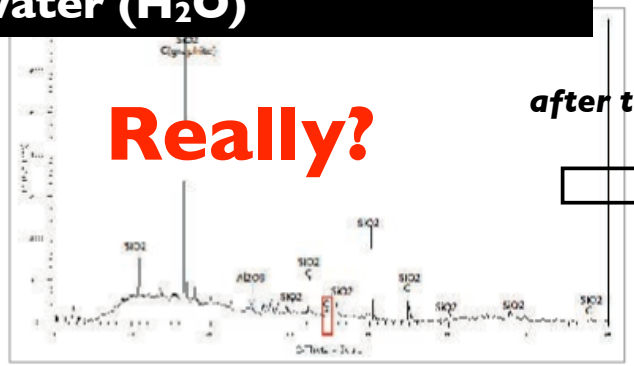
after the heating at 900C



30~900℃

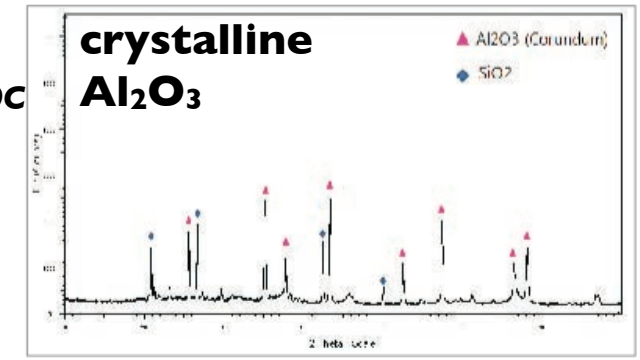
amorphous Al_2O_3 (explosion) + water (H_2O)

XRD



(Before heat treatment)

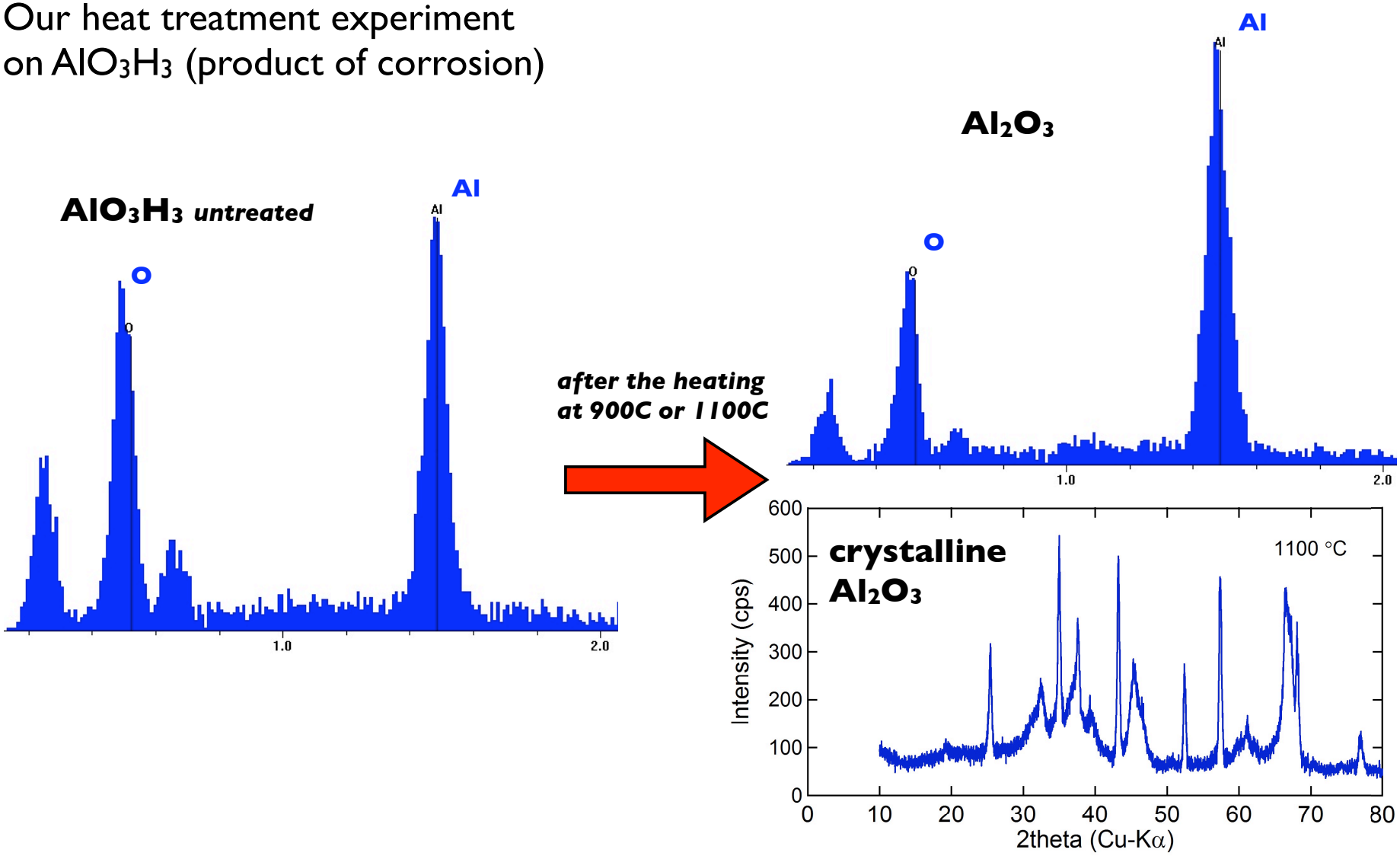
after the heating at 1200C



(After heat treatment)

The JIG's interpretation in their final report page 287: "If a crystalline aluminum oxide is found in heat-treated material, in which no crystalline aluminum oxide nor crystalline aluminum was found originally, the (original) material should have an amorphous aluminum oxide as an ingredient in it."

Our heat treatment experiment
on AlO_3H_3 (product of corrosion)

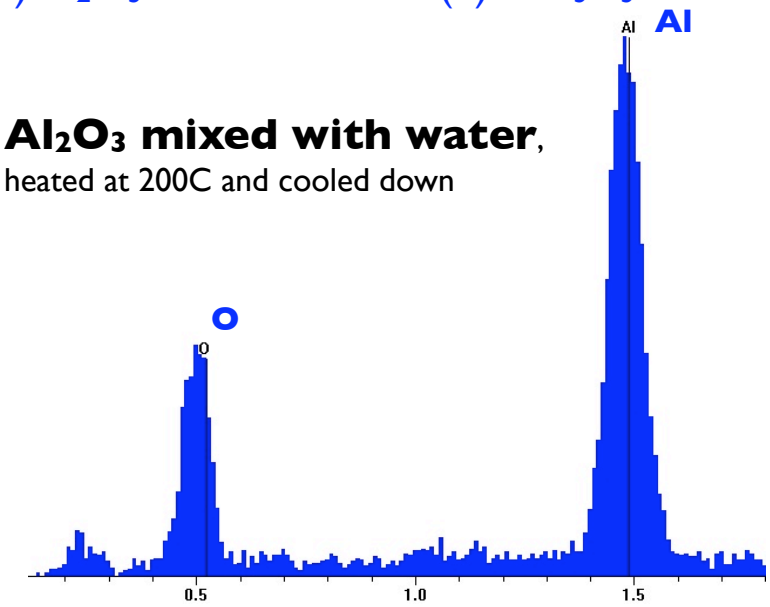


When heated to 900C or 1100C, aluminum hydroxide (AlO_3H_3) turns into aluminum oxide (Al_2O_3).

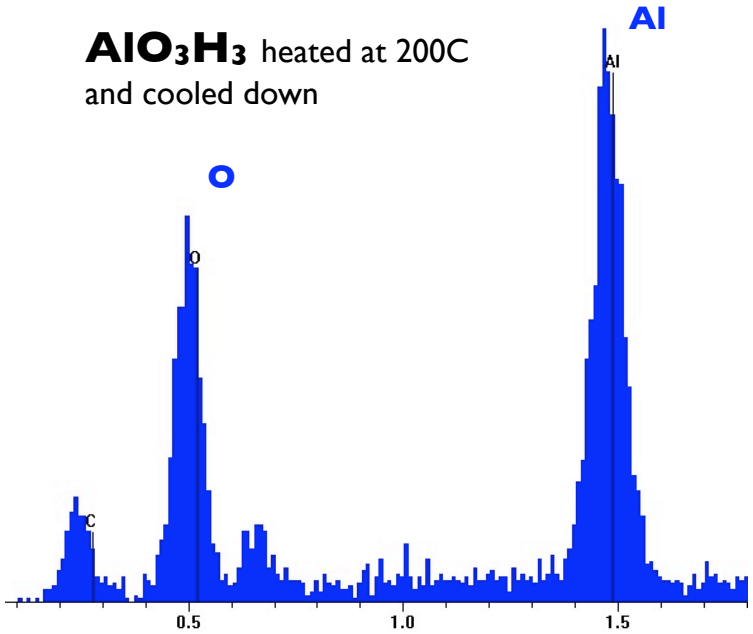
Then, what really is the white powder, amorphous aluminum oxide (the product of explosion) mixed with water (H_2O) or aluminum hydroxide (the product of corrosion)?

Our EDS data obtained from two heat treated samples at 200C:
(1) Al_2O_3 with water and (2) AlO_3H_3

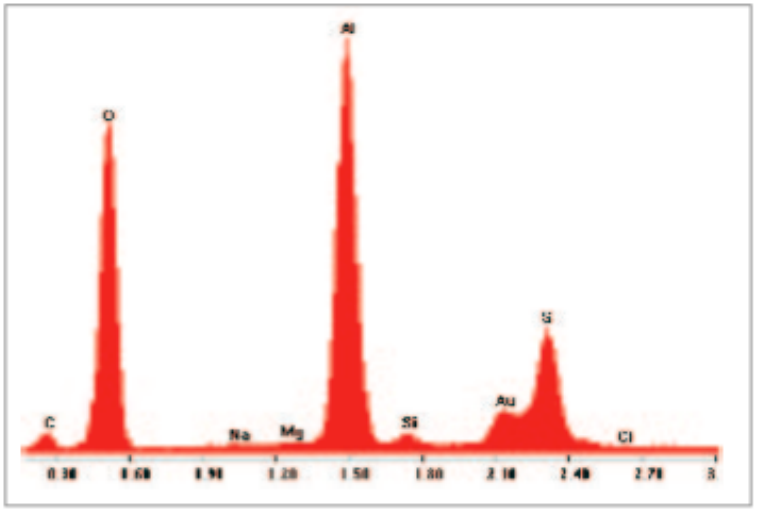
Al_2O_3 mixed with water,
heated at 200C and cooled down



AlO_3H_3 heated at 200C
and cooled down



The JIG's EDS data from the adhered sample heated at 200C

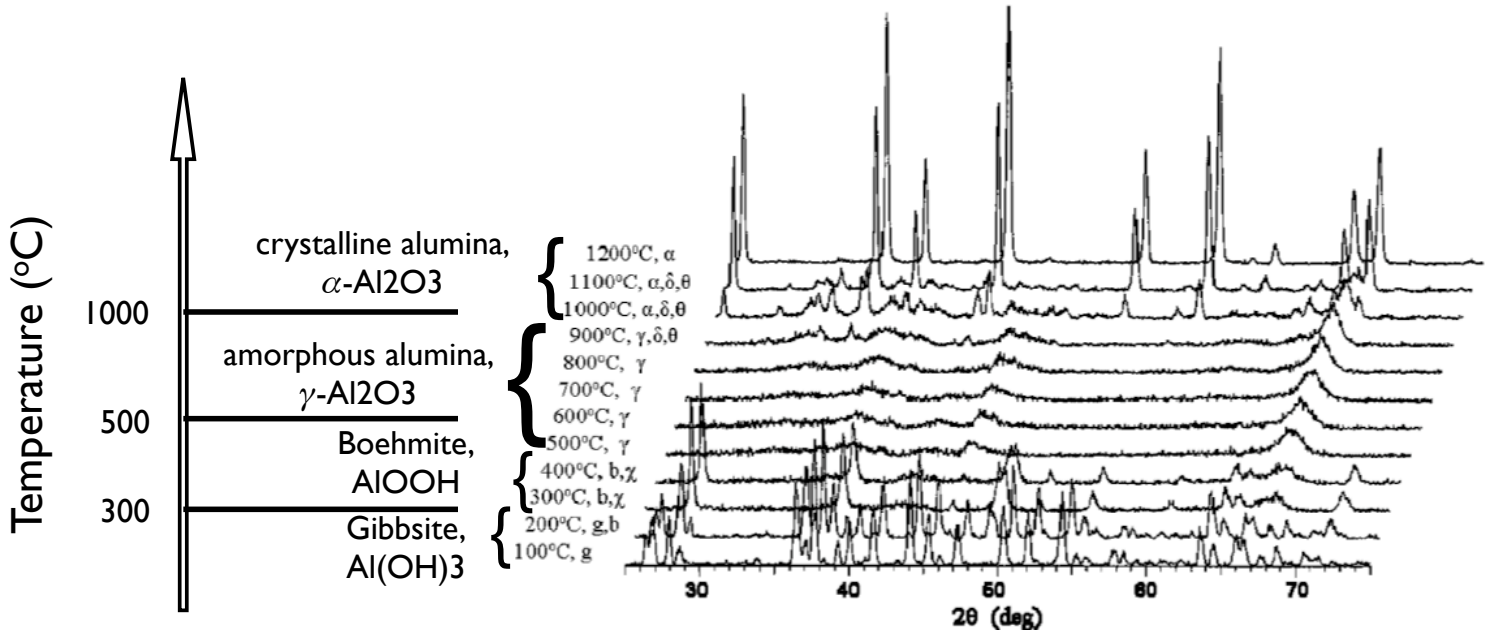


30~200℃

The JIG's EDS data (left) is close to the EDS data of AlO_3H_3 (above right) than to that of Al_2O_3 with water (above left). This indicates that the JIG's adhered materials are not amorphous aluminum oxides as the JIG claimed, but they are aluminum hydroxides that have nothing to do with explosion.

Previous XRD study on the phase transitions upon heating from aluminum hydroxides (Gibbsite and Boehmite) to aluminum oxides (amorphous and crystalline alumina)

M. R. Hill, T. J. Bastow, S. Celotto, and A. J. Hill,
"*Integrated Study of the Calcination Cycle from Gibbsite to Corundum*", Chem. Mater. vol. **19**, 2877-2883 (2007).



This previous XRD study is consistent with our conclusion that the JIG's adhered materials are aluminum hydroxides that have nothing to do with explosion.

Two Evidence for Two Key Links in the Cheonan report

Both links must hold in order for the JIG's conclusion to be correct.

North Korean Torpedo

The blue korean mark "No 1"

Explosion of the Torpedo

The EDS and x-ray data of three "adsorbed materials"

Sinking of Cheonan

Both links are not real.

"Meeting a whale in a mountain..."

ROK JIG's response on June 29, 2010 to questions about their inconsistent EDS/XRD data and interpretations
- "Our results are the first discovery in the world"
- Getting these results are "like meeting a whale in a mountain"

Science is a realm of truth, but the ROK JIG is pushing it into a realm of belief

nature Vol 439|12 January 2006

NEWS David Cyranoski

Verdict: Hwang's human stem cells were all fakes

Korean bioethicists call for inquiry into stem-cell work

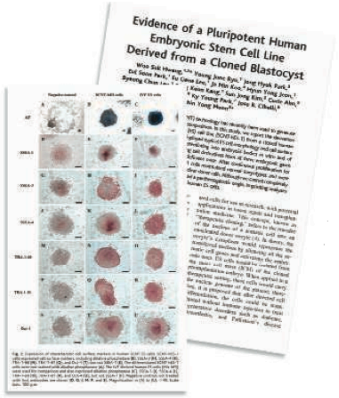
David Cyranoski, Tokyo

NATURE | VOL 429 | 3 JUNE 2004 | www.nature.com/nature

LETTERS

edited by Etta Kavanagh

Editorial Retraction



THE FINAL REPORT FROM THE INVESTIGATION COMMITTEE of Seoul National University (SNU) (*1*) has concluded that the authors of two papers published in *Science* (*2*, *3*) have engaged in research misconduct and that the papers contain fabricated data. With regard to Hwang *et al.*, 2004 (*2*), the Investigation Committee reported that the data showing that DNA from human embryonic stem cell line NT-1 is identical to that of the donor are invalid because they are the result of fabrication, as is the evidence that NT-1 is a bona fide stem cell line. Further, the committee found that the claim in Hwang *et al.*, 2005 (*3*) that 11 patient-specific embryonic stem cells line were derived from cloned blastocysts is based on fabricated data. According to the report of the Investigation Committee, the laboratory "does not possess patient-specific stem cell lines or any scientific basis for claiming to have created one." Because the final report of the SNU investigation indicated that a significant amount of the data presented in both papers is fabricated, the editors of *Science* feel that an immediate and unconditional retraction of both papers is needed. We therefore retract these two papers and advise the scientific community that the results reported in them are deemed to be invalid.

As we post this retraction, seven of the 15 authors of Hwang *et al.*, 2004 (*2*) have agreed to retract their paper. All of the authors of Hwang *et al.*, 2005 (*3*) have agreed to retract their paper.

Science regrets the time that the peer reviewers and others spent evaluating these papers as well as the time and resources that the scientific community may have spent trying to replicate these results.

DONALD KENNEDY
Editor-in-Chief

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