

Underkarat Jewelry: The Perfect Crime?

Investigations and Analysis of Jewelry Using XRF

Don Kloos



DXC 2002: Applications of X-ray Analysis to Forensic Materials

“Under-what?”
“What’s The Big Deal?”



The K-Team

Underkarat Jewelry: The 'Perfect Crime'?

- Background: jewelry and underkarating
- Background: jewelry and XRF
- Case studies: investigations with XRF

The Law

- Federal law created 1906 / amended 1976
- Defines guidelines for gold jewelry
- FTC – federal jurisdiction
- US Customs: imports 10K minimum and copyright infringement

The Rules

- Karat value must be labeled / tagged, or stamped with registered trademark
- 10K minimum in USA
- 3PPT negative tolerance – solid cast jewelry
- 7PPT negative tolerance - soldered jewelry
- 1 karat = 1 / 24 part gold (4.17 wt%)

Gold Karat Definitions (cast)

KARAT	PLUMB % Au	MIN. WT %
10K	41.7	41.4
14K	58.3	58.0
18K	75.0	74.7

USA Jewelry Industry

- WGC: USA retail gold jewelry \$ 16 B / yr
- WGC: 400 tonnes gold / yr - as jewelry
- ~ \$ 8B sold through large outlets
- ~ \$ 8B sold by small shops

The Crime

- Underkarat jewelry: gold content is less than is represented (below title)
- Fraud: deceptive representation
- Crime usually goes undiscovered
- Greatest loss at the retail level (consumer)
- Virtually no government enforcement

Underkarating

- “Rare mistake” in high-end / retail chains
- “Bargain” stores ~ 50% suspect underkarat
- Industry estimate: a few % to 30%
- Underkarating shortcuts gold usage:
 - ‘a little gold on a lot of volume’
- Consumer loses all retail value
- Honest jewelers at competitive disadvantage
- Linked to Medellin drug cartel (operation Polarcap 1990, Los Angeles)

Theoretical Consumer Loss

- Not 29 oz. Wheaties in a 32 oz. package
- Not local butcher with thumb on the scale
- Not a only a ‘few bucks less gold’
- Underkarat jewelry legally has *no* retail value
- Consumer loses all retail value
- Consumer loss = paid retail price – residual gold scrap value
- No government monitoring in USA - priorities

Theoretical Consumer Loss Estimates

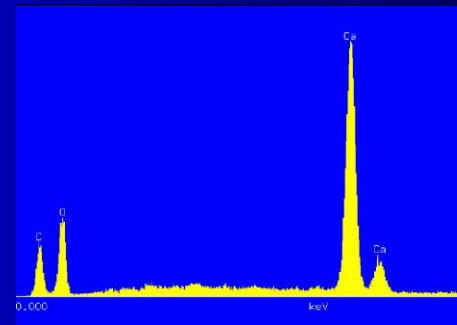
- Example 1: Assume 10% underkarating
 - 10% of \$16B retail = \$1.6B
 - Residual gold scrap value = \$ 0.4B
 - Net loss to consumer \$1.2B
- Example 2: Assume only 1% underkarating
 - Net loss to consumer \$120M
- Consumer losses \$0.1B to \$1B range

Summary

- Underkarating: consumer fraud and theft
- Cost to consumer and industry is substantial
- Crime goes undetected for the most part
- Government enforcement is negligible

About Jewelry and XRF

- Jewelry characteristics
- XRF characteristics for jewelry application
- Typical XRF data and uses



Typical Jewelry Alloys

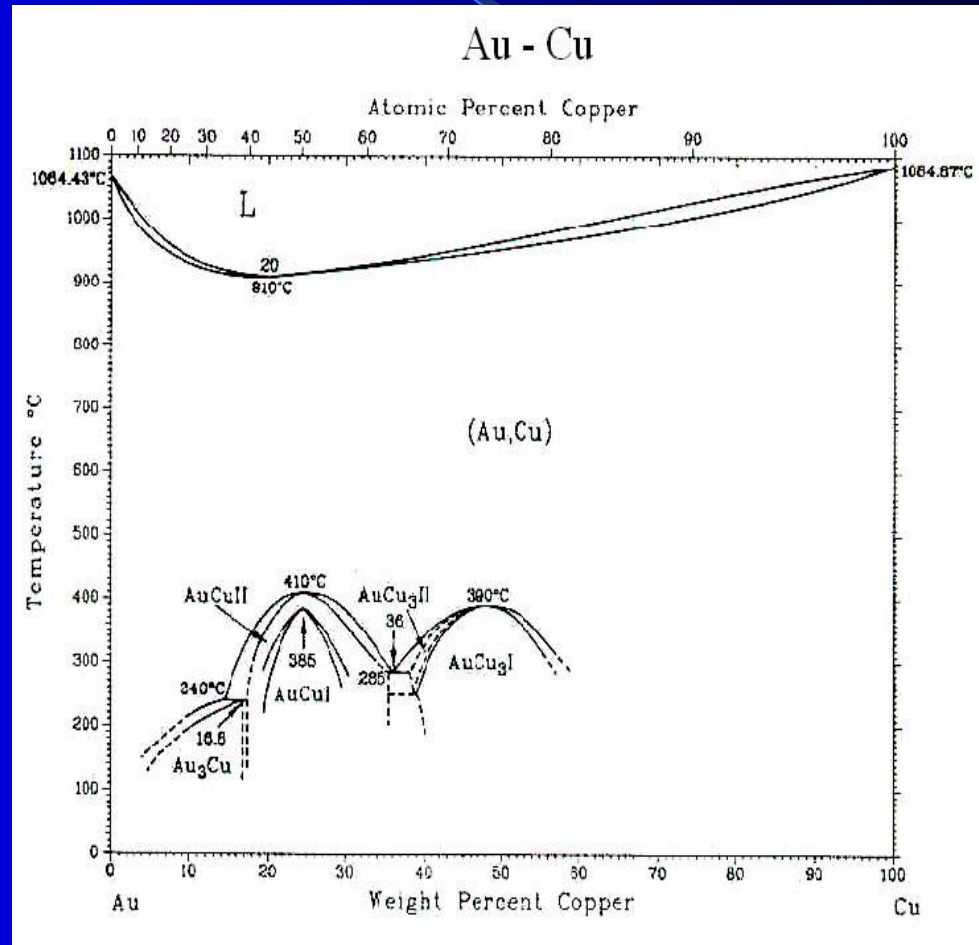
<u>Alloy</u>	<u>Au %</u>	<u>Ag %</u>	<u>Zn %</u>	<u>Cu %</u>	<u>Ni %</u>
10K Yellow	41.7	11	6	41	0
14K Yellow	58.3	7	5	30	0
14K White	58.3	0	8	25	9
18K Yellow	75.0	12.5	0	12.5	0

Jewelry Types

- Cast (lost wax investment)
- Extruded / Stamped
- Multi-colored
- Soldered
- Plated
- Electroformed
- **Each with unique homogeneity characteristics**

Heterogeneous Jewelry Alloys

- Highest melting point fraction solidifies first
- Outside may be richer in Au than interior



Heterogeneity: Plating Effects

24K over-plate, u-Inch	14K Yellow, XRF Wt % Au	18K Yellow, XRF Wt % Au
0.0	58.10	75.08
1.9	59.19	75.47
3.2	59.94	75.76
5.1	60.90	76.21

Heterogeneity: Solder Effects

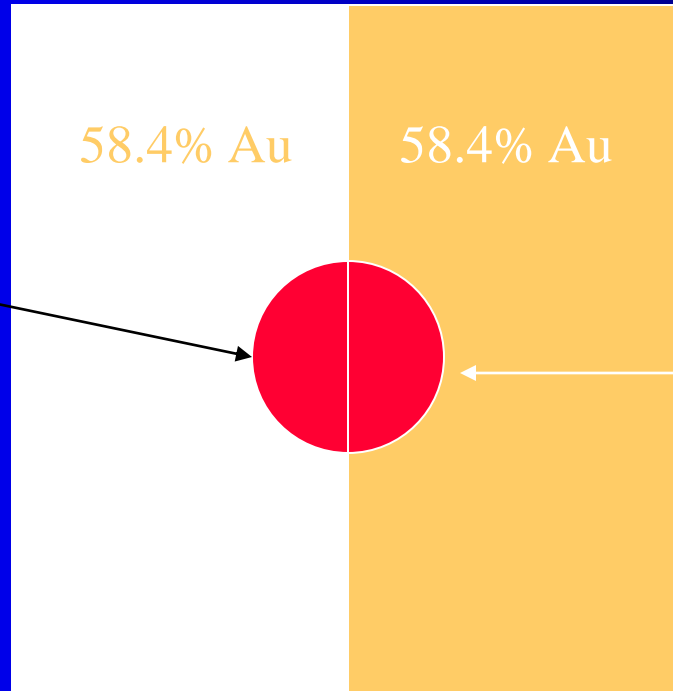
14KW

14KY

58.4% Au

58.4% Au

XRF measurement
area, 3mm diam.



XRF Result:
59.1% Au

Two alloys together

“The Jewelry Judge”: Fire Assay / Cupellation

- The referee assay method
- Destructive gravimetric analysis
- Time : hours to days
- Absolute accuracy limit: 0.02wt% Au
- Practical accuracy: 0.02 – 0.25wt% Au



XRF Is Surface Analysis

- Depends on alloy and x-ray escape depth
- Effective depth of analysis ~ 10um for most jewelry alloys
- XRF is practically a surface measurement

Desired XRF Performance

- Legal tolerances are 3 to 7 ppt Au
- Precision and Accuracy ideally within legal tolerances ~ 1ppt
- Very high precision and accuracy is desired

XRF In Production Casting

- Limited known alloys are used
- Matrix matched type standards
- Sample preparation closely controlled
- Accuracy can be within 1ppt Au



Casting Site: XRF - Fire Assay

Test Duration	7 Months
No. of Assays	191
Avg. Difference	- 0.01 Wt% Au
Absolute Avg. Diff.	0.03 Wt% Au
Max. Difference	- 0.10 Wt% Au

XRF and Refining Scrap

XRF, Wt% Au	ASSAY, Wt% Au
72.8	73.5
68.8	70.5
58.5	60.0
47.9	47.7
40.2	40.4
31.0	31.3

WDXRF 'standardless' analysis (Uniquant)

Summary

- Jewelry and karat alloys are heterogeneous
- Heterogeneity errors $\sim 1 + \text{Wt\% Au}$
- XRF – Fire Assay parity is high under ideal and controlled conditions

XRF Jewelry Investigations

1. San Francisco District Attorney Vs IPI
2. NBC Dateline
3. US Customs
4. NY State Attorney Vs NYC Jewelers



San Francisco DA Vs IPI Gold

- SFDA raided IPI outlets / arrested owners
- Charged felony grand theft - selling underkarated jewelry
- Confiscated 15,000 pieces of jewelry
- Civil liability \$80M maximum fines
- Both parties stipulated to have XRF sort underkarat from legal jewelry
- XRF found “relevant, reliable, trustworthy”

SFDA Test Parameters

- Benchtop EDXRF
- SiLi detector / LN2
- FP w/ 1-Standard
- 300 sec
- Beam size 3mm
- Rh tube , 50KV, 13W
- 1-sigma: 0.13% rel



Seiko SEA-2000 EDXRF

SFDA Test: XRF Vs Assay

Description	XRF, Karat	Assay, Karat
Crucifix	8.71	8.45
Cadillac Charm	13.59	13.57
Nugget Charm	13.86	13.89
Rope Chain	9.42	9.38
Crucifix	10.12	10.0
Pinky Ring	8.67	8.66
Ring	12.17	12.21
Butterfly Charm	14.03	13.86
Elephant Chain	15.05	13.38
Chain Necklace	14.24	14.51

SFDA Summary

- XRF 80% agreement with assay judgments
- Possible errors from solder, plating
- Thousands of pieces ‘legally’ sorted
- XRF found “relevant, reliable, trustworthy”
- Establishment of XRF as viable tool

NBC Dateline Test 1995

“All That Glitters”

- Tabloid TV takes a swing at underkarating
- NBC ‘shopped’ stores and assayed jewelry
- NBC reported results on Dateline 1995
- Exposed and confronted underkarating
- Contacted to analyze jewelry by XRF

NBC Test Parameters

- Small spot EDXRF
- SiLi detector / LN2
- FP w / multi standards
- 50 seconds LT
- Beam size 500um
- 50KV, air
- 1-sigma: 0.5% rel



Kevex Omicron

Dateline Scorecard: XRF Vs Fire Assay

No. of comparisons	46
No. of agreements on assay judgments	41
% Parity	89
No. underkarat samples (fire assay)	16
No. of underkarat detections, XRF	11

Dateline Scorecard: Cast / Solid Jewelry Only

No. of comparisons	25
No. of agreements on assay judgments	24
% Parity	96
No. underkarat (fire assay)	10
No. of underkarat detections, XRF	9

Dateline Summary

- XRF screening reliability 89+ %
- Dateline deferred to fire assay ultimately
- All 5 XRF failures were on bracelets
- Bracelets likely plated, soldered
- Effectiveness improved to 96% on 'solids'
- Dateline case comparable to SFDA case

US Customs: Overkarating

- Field test to screen imported jewelry parcels
- Rings declared at 14K with 1Ct CZ gems
- XRF assayed gold rings at 18K
- XRF confirmed no CZ (Y and Zr)
- Under-declared value exposed

US Customs Test Parameters

- Small spot EDXRF
- Proportional counter
- Beam size: 300um
- FP w/ 1-standard
- W, 50KV, 1ma
- 90 seconds
- 1-sigma: 0.13% rel



CMI 950

US Customs Summary

- US Customs able to take action on parcel
- XRF uncovered smuggling and fraud
- US Customs test procedures includes “XRF screening” for gold content of jewelry
- Virtually no routine inspection occurs

New York State Attorney Vs New York City Jewelers

- Jewelers Vigilance Committee investigation
- Undercover shopping and XRF testing
- Jewelry less than 10K found by XRF
- Submitted XRF data to NY State Attorney
- Legal actions and \$125K in fines
- 2 Manufacturers, 18 distributors / retailers
- Test Parameters similar to SFDA

NY State Attorney Summary

- Precedent setting case for XRF:
- Successful investigation, prosecution, penalty based solely on XRF data.
- Effective use of XRF in forensic application
- JVC: “Clear and convincing evidence”
- Industry self-enforcement example

Conclusions

- Underkarating is substantial and costly
- It is largely undetected and un-enforced
- XRF parity to fire assay 80 – 100%
- XRF effective in forensic investigations of jewelry underkarating
- XRF established as viable method

XRF: Protection for the Consumer and Jewelry Industry

