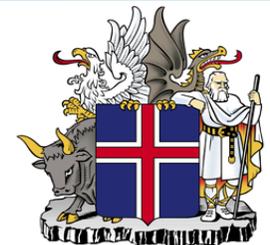


TENORM IN GEOTHERMAL APPLICATIONS IN ICELAND

NSFS 2015 24/8/2015

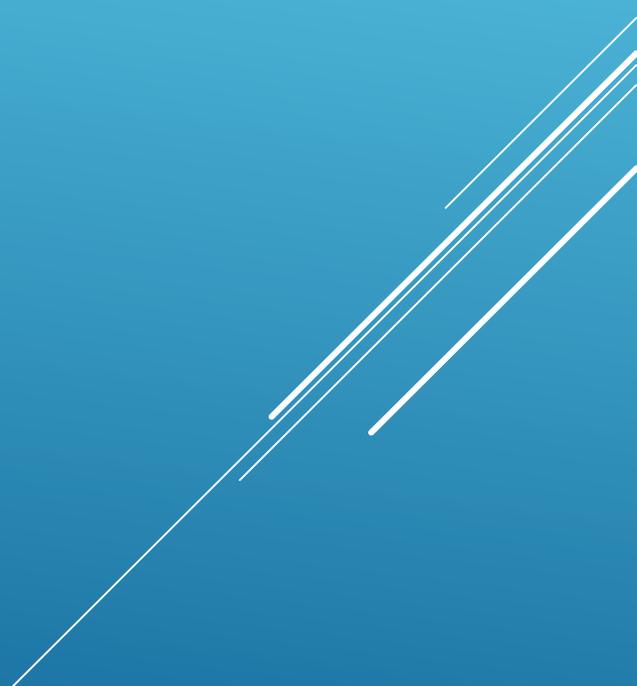
Þorgeir Sigurðsson



GEISLAVARNIR RÍKISINS
ICELANDIC RADIATION PROTECTION INSTITUTE

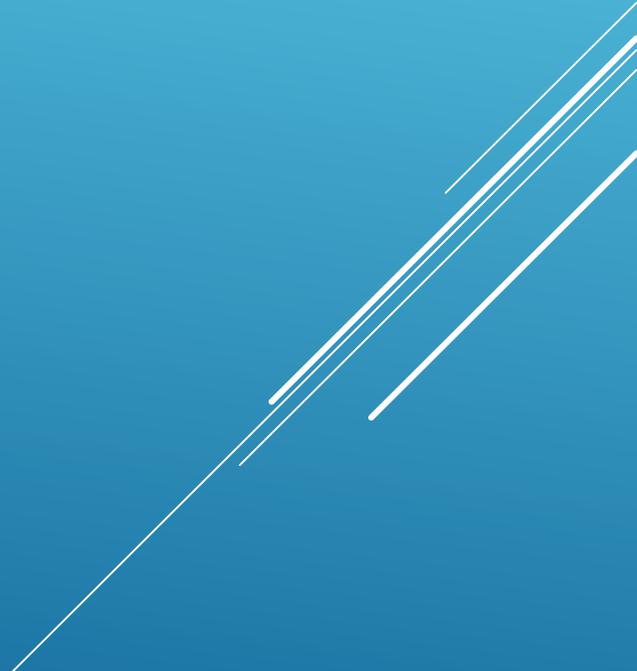
It has recently been verified that hard sulphide scales in **geothermal surface pipes** in Iceland **contain NORM** from the U-238 chain, above the exemption limit of 10 Bq/g. This was not expected since levels of natural radioactivity are very low in Iceland.

**A SURPRISE: HARD SCALES CONTAIN
TENORM**

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The discovery of TENORM in Iceland provides an example of useful Nordic co-operation, involving actors from **Iceland, Norway, Denmark, Finland and NSFS.**

NORDIC COOPERATION

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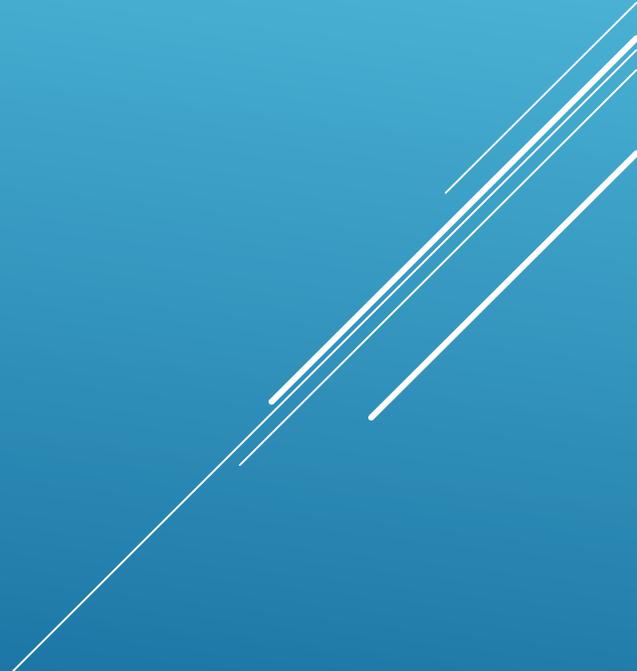
It began with an email from NRPA Norway **6/2/2014**

Hello... we wish to conduct a survey...

(perhaps in conjunction with your geothermal industry?)...

do you have contact information for or any names of any
companies that measure NORM... ?

**AN EMAIL FROM NORWAY BECAUSE
OF AN EU PROJECT**

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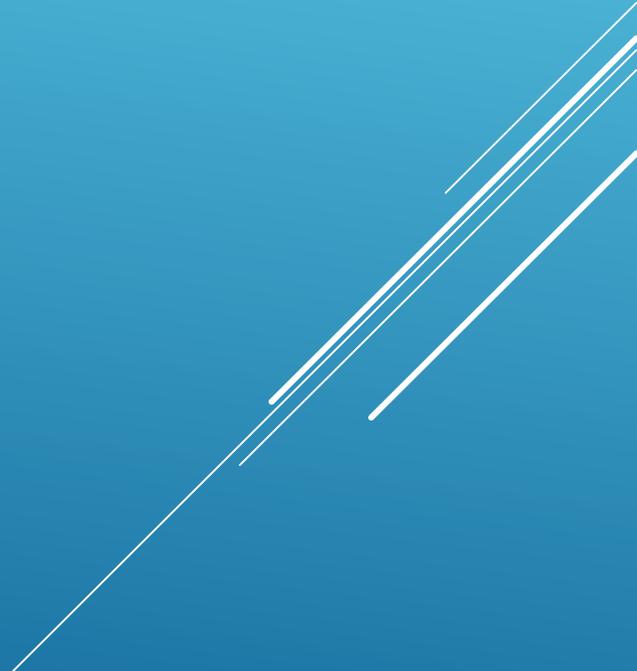
My instant reply:

“To my knowledge there is **no industry producing NORM...**

The geothermal industry does not seem to produce anything with increased activity...”

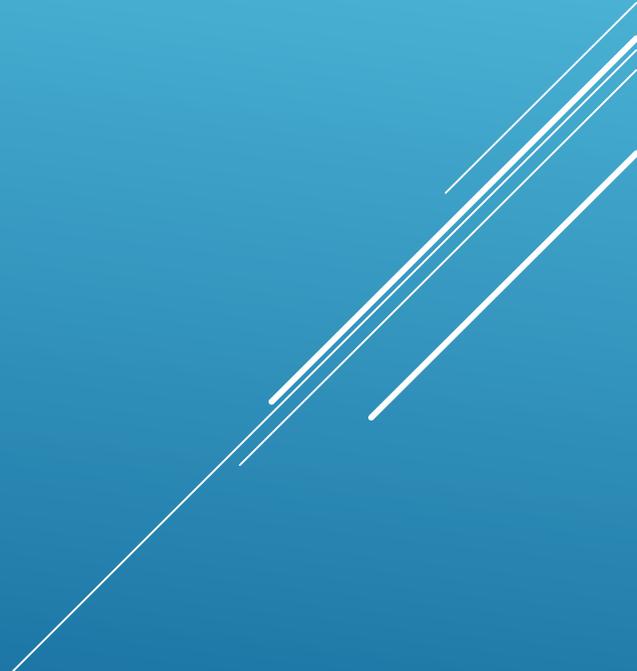
Þorgeir Sigurðsson

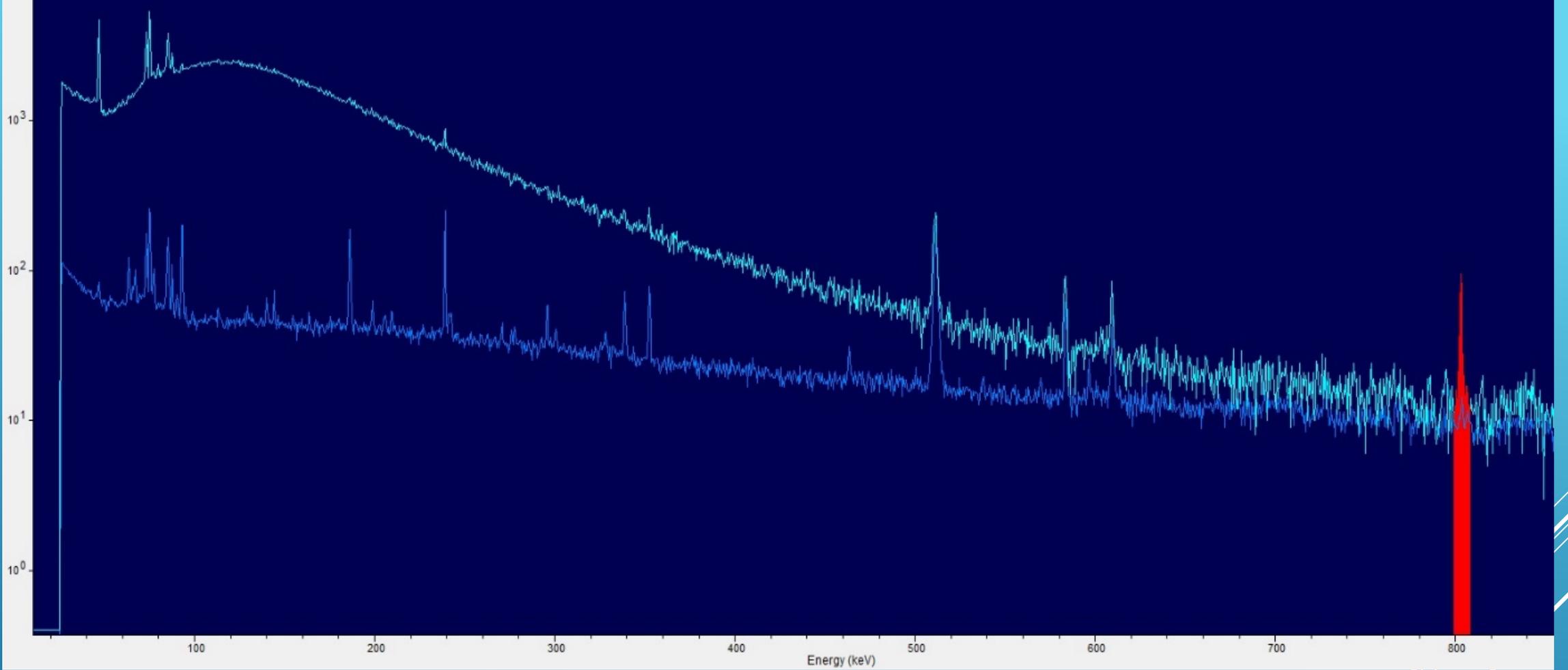
THE DEFAULT ANSWER: NO NORM

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Thinking better about it I did however some measurements on samples of scales and to my surprise found **beta and alpha radiation** in samples from one geothermal site. The gamma radiation was weak, it did however suffice to identify two radionuclides from the U-238 decay chain.

HOWEVER...

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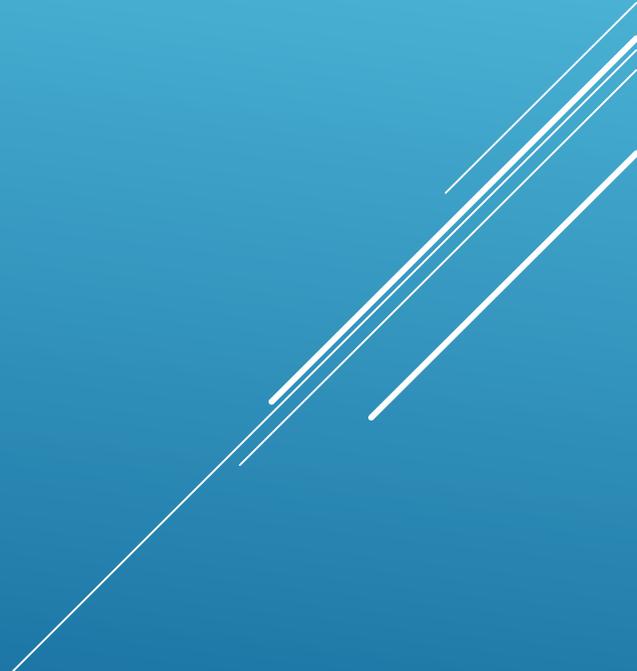
A GAMMA-SPECTRUM EMITTED BY THE SCALING. A PEAK FOR **PO-210** IS HIGHLIGHTED IN RED. A LOW VOLTAGE PEAK AT 47 KEV DUE TO **PB-210** IS ALSO VISIBLE. A BACKGROUND SPECTRUM WITHOUT THESE PEAKS IS SHOWN FOR COMPARISON

I took a sample to Risø 24-25/2/2014

Email from Risø 3/3/2014 stated:

... small amount of Pb-210 detectable...

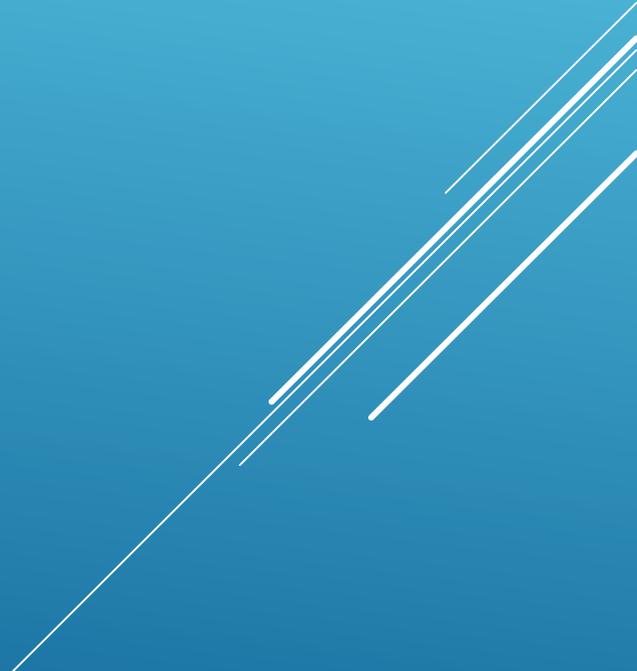
FIRST STOP: RISØ

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In a **NORGIR meeting** in Reykjavik **11/9/2014** I raised the possibility of TENORM in Iceland (see poster S11-04)

The Finnish and the Norwegian delegates took home samples from the same piece of scaling that had gone to Risø

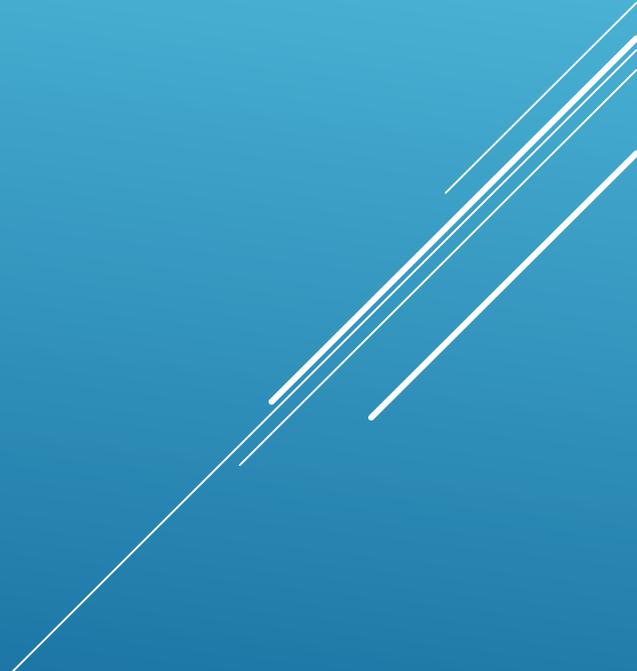
A NORDIC EXPERT MEETING

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An email from Finland three weeks later **3/10/2014** from Seppo Klemola

... ~ 20 Bq/g Po-210...

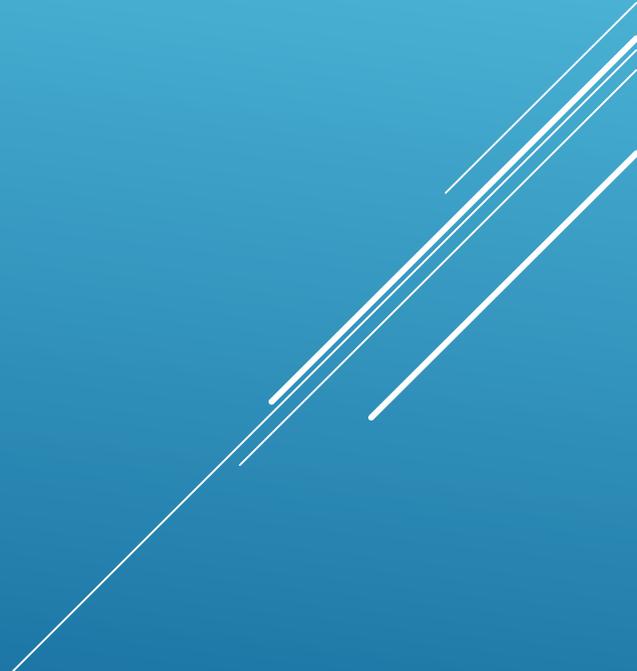
FIRST ESTIMATE CAME FROM FINLAND

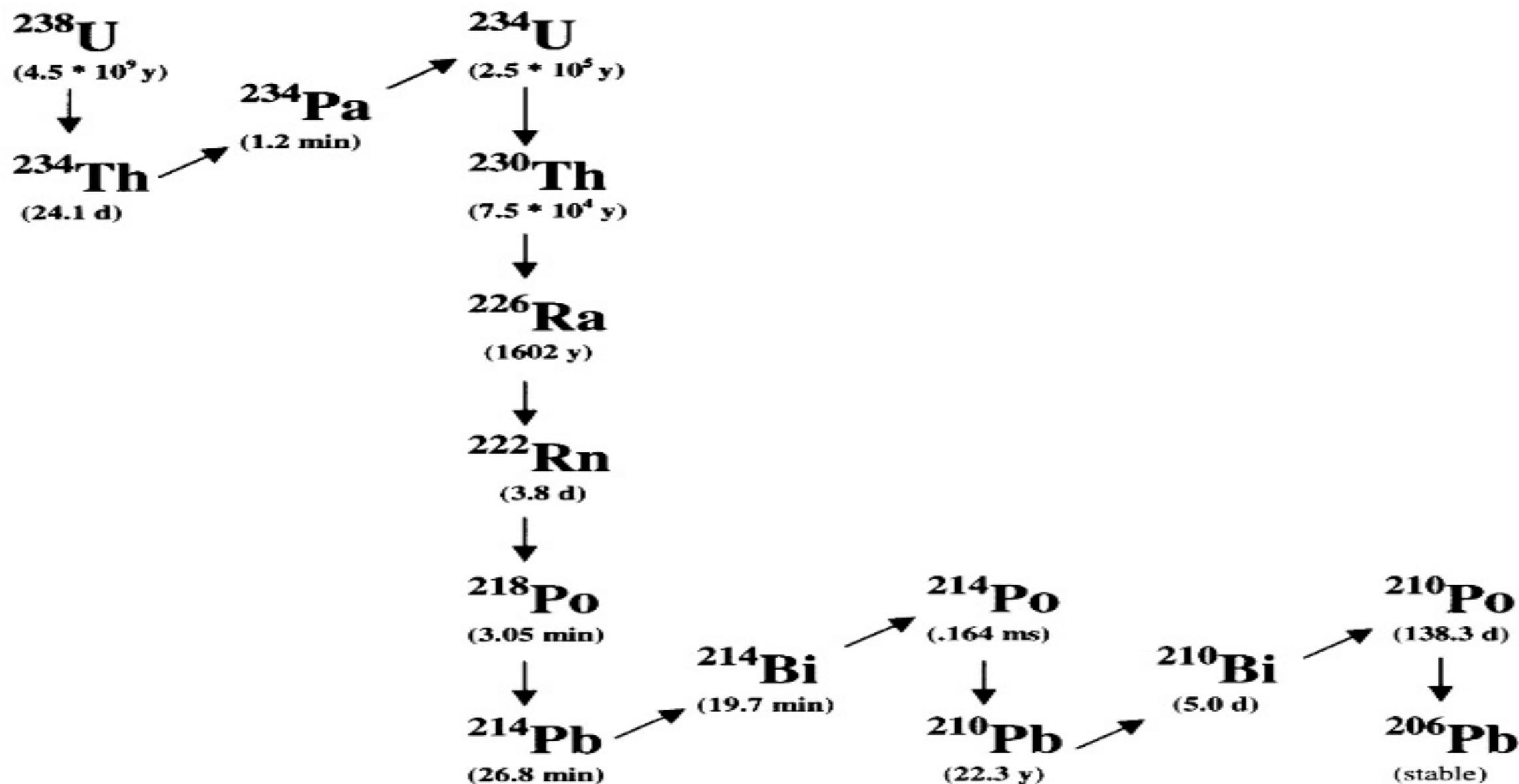
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A month later **7/11/2014** an email from Norway arrived: (report dated **31/10/2014**)

... ~ 25 Bq/g Pb-210...

AN ESTIMATE FROM NORWAY FOR PB

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I drafted a paper and sent an abstract to the secretary of the upcoming XVII NSFS conference (its text is in the Program Abstracts distributed)

An email from **20/4/2015** said ...

...has been **accepted for Oral presentation** (this is it)

AN UP-COMING NSFS CONFERENCE

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I sent a sample from the same scaling as before for **an accredited** analysis from Finland dated: **2/6/2015**

Po-210 20 Bq/g

Pb-210 4.4 Bq/g

The low value for Pb raises questions

THE FIRST ACCREDITED ANALYSIS



Well no 22
After one year of operation in 2007

A PIPE WITH NORM



Samples from pieces laying on the ground were taken from the **most productive wells** and a batch of samples went for accredited analyses.

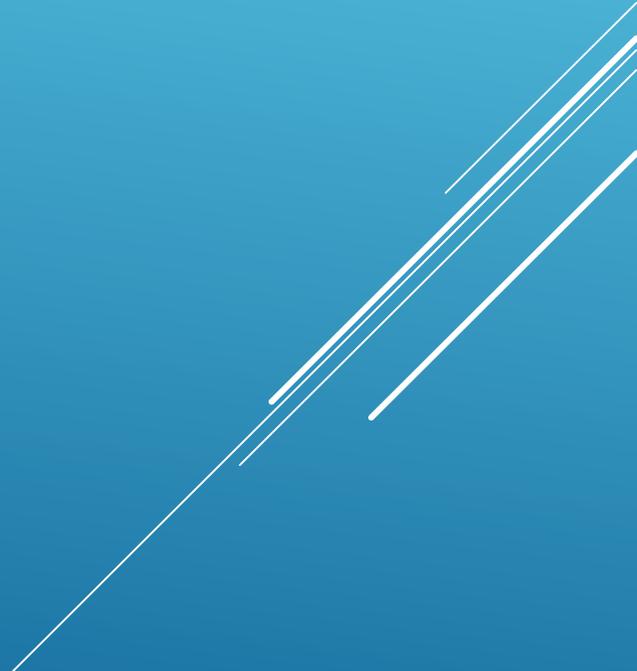
A report dated **31/7/2015** gave:

123-214 Bq/g for Po-210

34-52 Bq/g for Pb-210

< 2 Bq/g for Ra-226

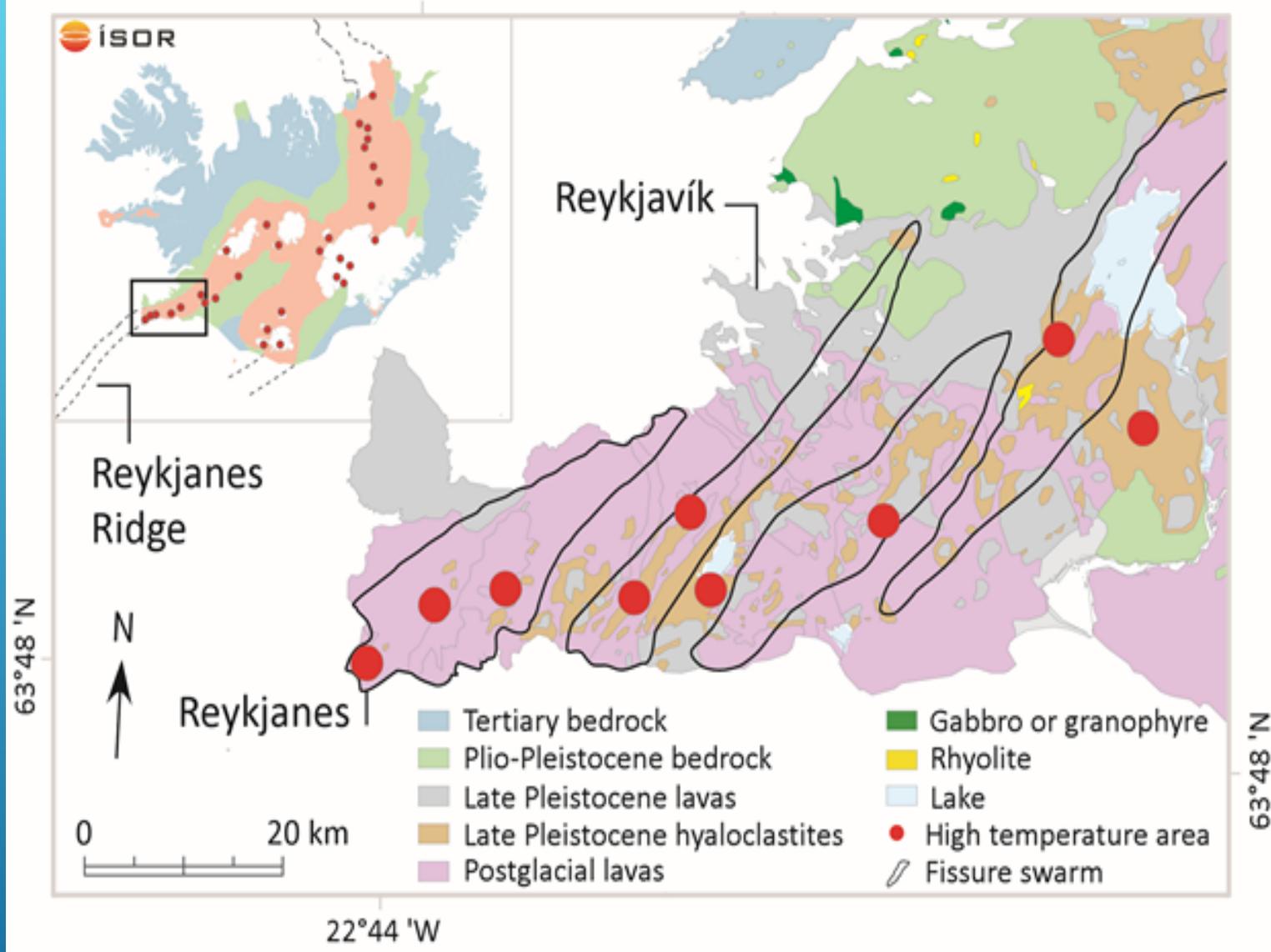
NEW STRONGER SAMPLES

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1-4 tons of hard sulphide scales are cleared from the geothermal pipes per year.

Sulphides include small amounts of galena (PbS)
(the chemical composition is known)

HOW MUCH?



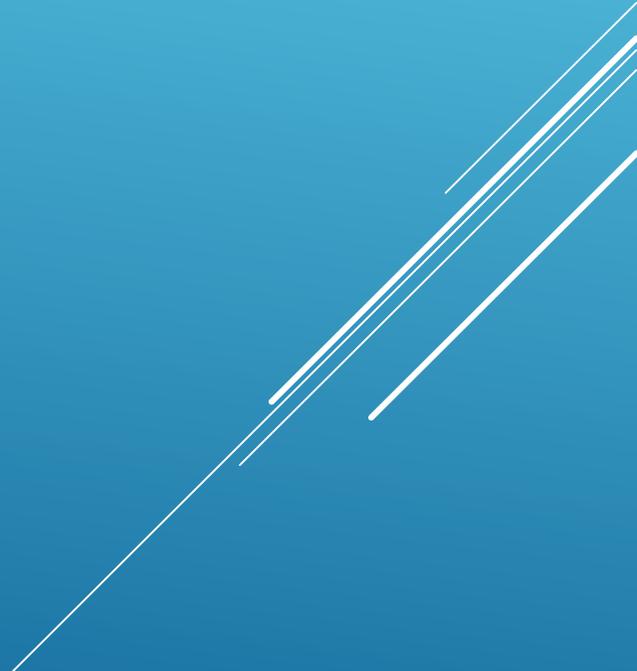
REYKJANES, 100 MW PLANT, SEA WATER

Radio-nuclide	Crude oil Bq/g	Natural gas Bq/m ³	Produced water Bq/L	Hard scale Bq/g	Sludge Bq/g
U-238	0.000 000 1–0.01		0.0003–0.1	0.001–0.5	0.005–0.01
Ra-226	0.0001–0.04		0.002–1200	0.1–15 000	0.05–800
Po-210	0–0.01	0.002–0.08		0.02–1.5	0.004–160
Pb-210		0.005–0.02	0.05–190	0.02–75	0.1–1300
Rn-222		5–200 000			
Th-232	0.000 03–0.002		0.0003–0.001	0.001–0.002	0.002–0.01
Ra-228			0.3–180	0.05–2800	0.5–50
Ra-224			0.5–40		

**IAEA REPORT ON NORM IN OIL AND GAS:
SCALES HAVE MORE PO-210**

Reference: TENORM in geothermal applications in Iceland in the NSFS XVII (2015) proceedings at www.NSFS.org for more information or contact me: ts@gr.s / ths185@hi.is

THANK YOU NSFS!

A decorative graphic consisting of several parallel white lines of varying lengths, slanted upwards from left to right, located in the bottom right corner of the slide.