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Single and multi-stage Poisson Processes: a case study for gold exploration

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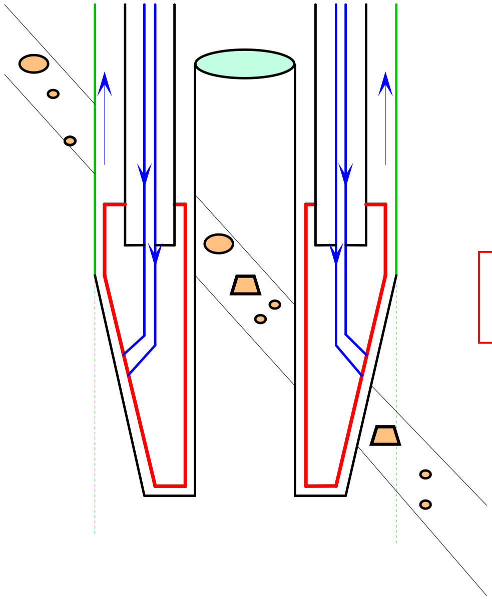
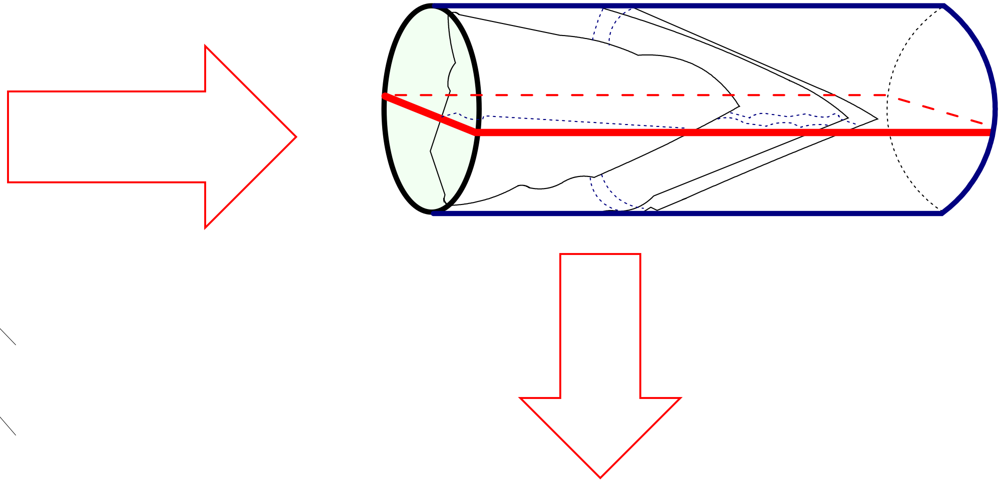
GECAMIN Conferences for Mining Celebrating 15 years

The Industry Standard for Gold





Standard 30-gram Fire Assay

Replicate 30g fire assays from a single 1-meter NQ core sample
Results expressed as g/t gold

0.524	1.722	0.436	0.664	0.611	0.546	0.490	**53.826**
0.574	0.528	0.557	0.557	0.527	0.529	0.490	0.519
9.739	1.052	6.852	0.668	1.052	0.677	0.468	0.831
0.948	0.742	0.588	0.555	0.744	0.188	1.600	0.725
1.591	0.800	1.400	0.677	0.670	0.749	1.817	0.846
1.200	0.640	0.587	1.078	0.769	**22.000**	0.983	2.383
2.609	1.235	2.017	0.857	1.765	0.833	0.913	3.583
0.703	0.664	0.688	1.417	1.591	0.715	7.235	0.734
0.505	0.492	1.278	0.698	0.669	1.261	0.527	0.794
3.017	0.685	0.674	0.655	1.296	2.765	0.983	0.785
1.374	1.191	1.27	0.549	0.672	0.587	2.122	1.374
0.693	0.570	0.896	1.052	0.609	1.339	0.592	0.541
0.668	0.568	0.584	2.852	0.681	0.652	0.360	0.948
1.339	0.597	0.670	0.589	0.703	0.597	0.530	0.590
0.538	0.503	1.278	**16.696**	0.522	2.417	0.704	0.666
0.739	0.636	0.638	0.641	1.113	**63.043**	1.722	2.174

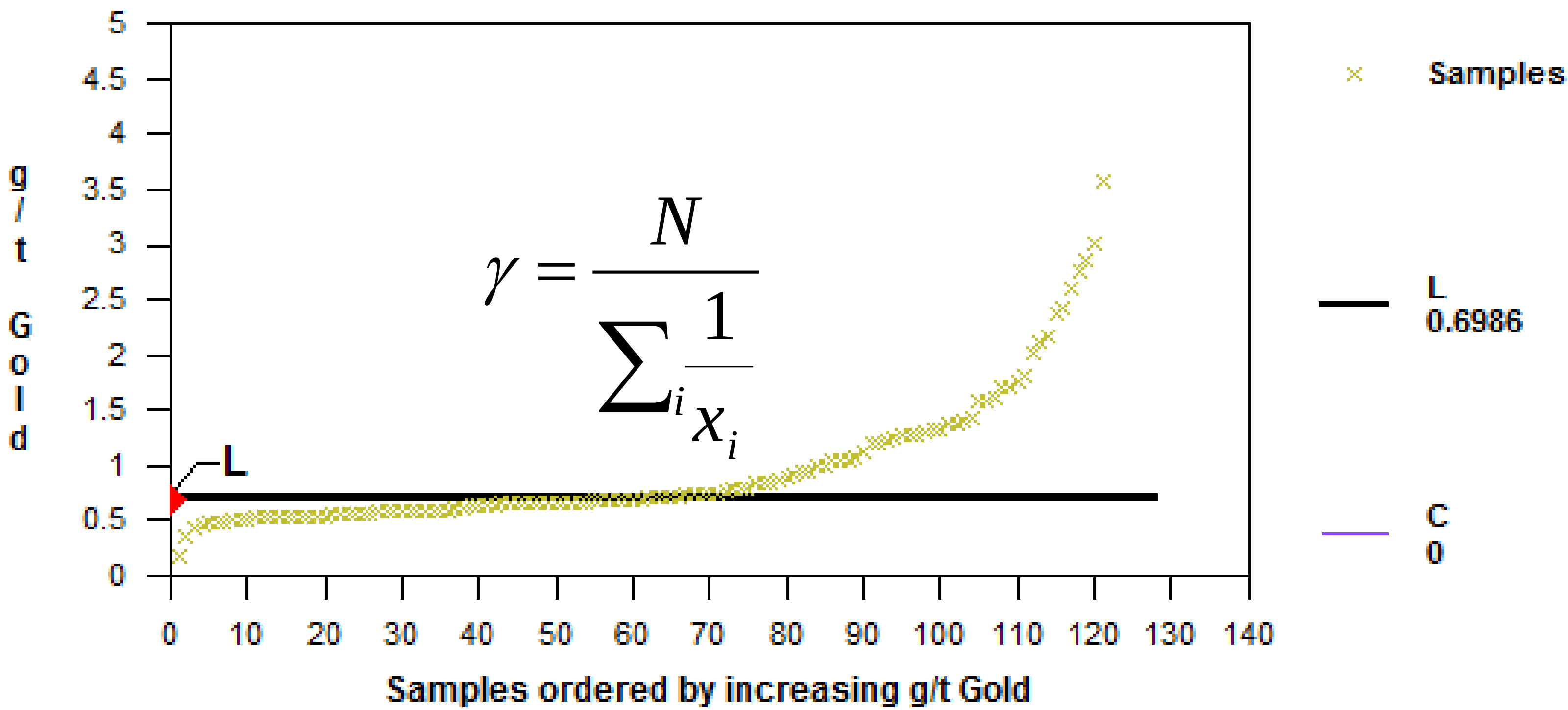
Average gold content: **2.311 g/t**

Low background content: **0.699 g/t**

Values in g/t gold of the 16 groups of 8 fire assays.

Group number	Average gold content in g/t
1	**7.350**
2	0.540
3	2.670
4	0.760
5	1.070
6	3.710
7	1.730
8	1.720
9	0.780
10	1.360
11	1.140
12	0.790
13	0.910
14	0.700
15	2.92
16	**8.84**
Overall average gold content	**2.311**

Low background gold content L calculated with harmonic means



$$\gamma = \frac{N}{\sum_i \frac{1}{x_i}}$$

$$L = \frac{\gamma_1 \cdot M_{S2}(a_L - \gamma_2) - \gamma_2 \cdot M_{S1}(a_L - \gamma_1)}{M_{S2}(a_L - \gamma_2) - M_{S1}(a_L - \gamma_1)} = 0.699\, g/t$$

Poisson model is a limit case of the binomial model.

$$P(x=r)=\frac{\theta^r}{r!}e^{-\theta}$$

with $r = 0, 1, 2, 3, \ldots$

θ is the hypothetical average number of gold particles per sample.

Calculating θ

From Ingamells and Pitard (1986): $$a_L = L + c\theta$$

$$\theta = \left(\frac{a_L - L}{s_1} \right)^2 = \left(\frac{2.311 - 0.699}{7.58} \right)^2 = 0.0452$$

Calculation of a Poisson distribution with $\theta = 0.0452$

Calculations performed using a gamma function and improved Stirling approximation:

$$P(x = r) = e^{-\theta} \cdot \theta^{r} \cdot r^{-r} \cdot e^{r} \left(\frac{\pi(6n+1)}{3} \right)^{-0.5}$$

$$P(x = 0) = 0.9558$$

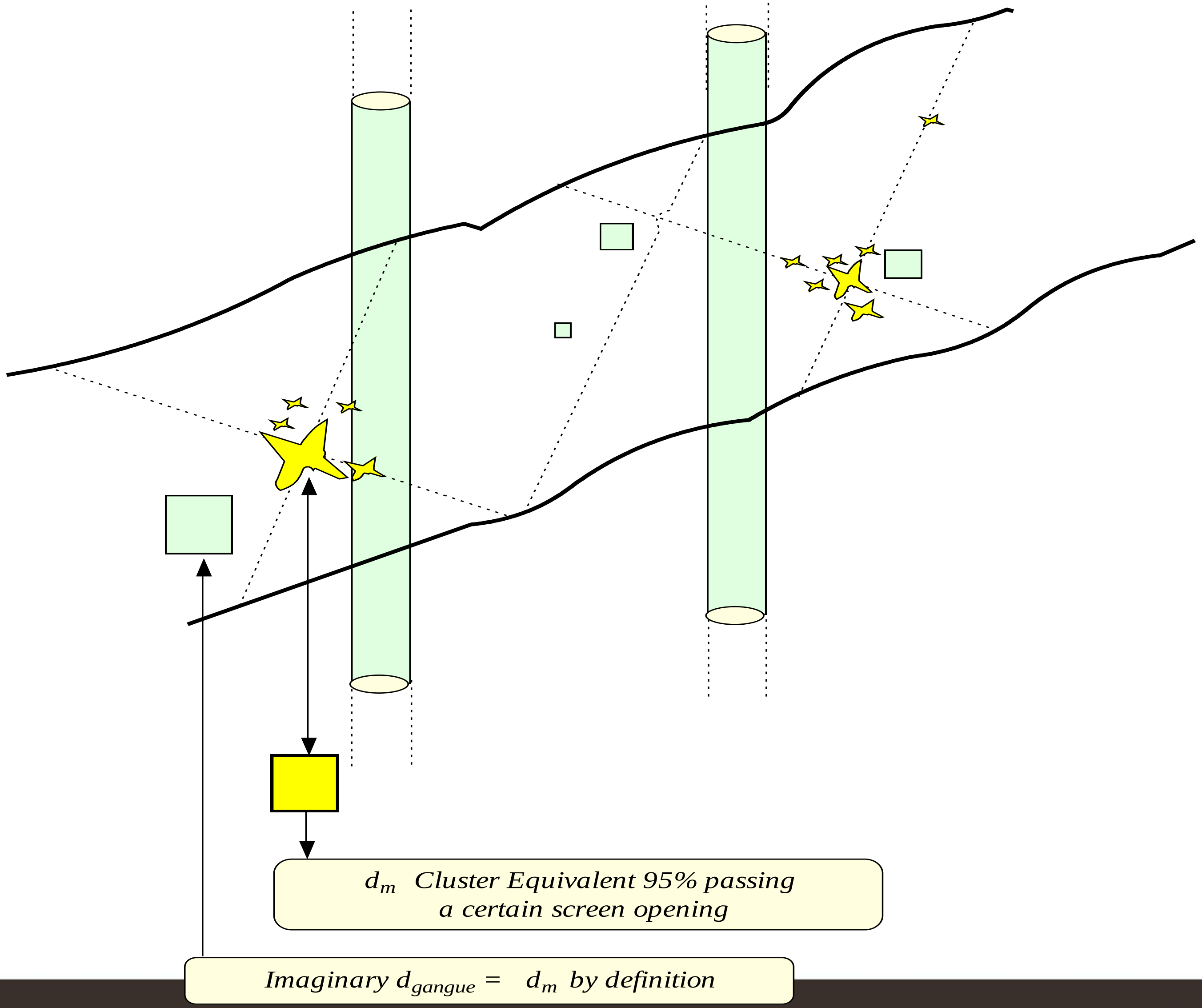
$$P(x = 1) = 0.04337$$

$$P(x = 2) = 0.0009775$$

$$P(x = 3) = 0.0000147$$

Important point: In this distribution there are no outliers.

HOW A DOUBLE POISSON PROCESS MAY TAKE PLACE



A cluster of 6 particles weighs about 0.00131 x 6 = 0.00786g and measures about 785 µm.

H is the gold content of a gold particle often alloyed in nature, leading to an average density around 16, therefore:

H = (1000000 x 16)/19.3= 829015 g/t

If the 1-m NQ core sample weighs 3840g and the average grade is 2.31 g/t, the contribution C of a single cluster is:

$$C = \frac{(0.00786)(829015)}{3840} = 1.70\, g/t$$

$$\mu = \frac{a_L - L}{C} = \frac{2.31 - 0.699}{1.70} = 0.95$$

Calculation of a Poisson distribution with $\mu = 0.95$

$$P(x=0)=0.386$$

$$P(x=1)=0.369$$

$$P(x=2)=0.175$$

$$P(x=3)=0.055$$

$$P(x=4)=0.0131$$

$$P(x=5)=0.0025$$

Important point: In this distribution there are no outliers.

Combining the respective probabilities of the two successive Poisson Processes

$P(x=0) = 0.967$

$P(x=1) = 0.027$

Obviously the largest damage by far
was the 30g fire assay
that was too small by two orders of magnitude.

What about the practice of cutting high grade during exploration ?

At one time, scientists became convinced that the Gaussian and lognormal models were universally applicable.

Many applications of statistical theory are based on these models.

A common error is to reject "**outliers**" that cannot be made to fit the Gaussian model or some modification of it as the popular lognormal model.

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0.739	0.636	0.638	0.641	1.113	63.043	1.722	2.174

It is very clear the true average gold content is **2.311 g/t, including all so-called outliers.**

Is this a demonstration that the practice of cutting high grade during exploration should be revisited and replaced by in-depth investigations?