January 26, 2016
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Re: Morphologies and Finenesses of Gold Grains from Samples 403, 406 and 416, CATS Project, Minnesota

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As requested, we mounted some of the previously reported gold grains from the above three samples and examined them by scanning electron microscope (SEM) to: (a) determine their physical morphologies; (b) acquire backscatter electron images of representative grains; and (c) measure the finenesses (i.e. %Au x 10) of the photographed grains. Unfortunately, none of the grains contained inclusions that might provide clues to their provenance. However, the fact that we previously recovered sperrylite grains from several of the nineteen submitted samples suggests a possible connection to the mafic and ultramafic rocks of the Duluth Complex.

As shown in Table 1, we successfully mounted nearly half of the grains from Samples 406 and 416 (25 of 56 and 22 of 49, respectively). In Sample 403, however, we were able to mount only 10 of the 66 available grains, mainly because 39 of these grains were exceptionally fine, with diameters of only 15 µm. The morphologies determined for these 10 grains are probably representative only of the coarsest grains in the sample which tend to be reshaped, not of the entire population, as 7 were found to be fully reshaped compared to only 10 of 66 in our original binocular microscope classifications.

We determined the morphologies of the grains from all three samples. We elected to focus our imaging and fineness determinations on Sample 406 because it had the most grains and many were photogenic. As in our earlier binocular microscope classifications, only a few grains were found to be reshaped – 7 of 25 versus 8 of 56 (Table 1). However, modified rather than pristine grains were found to be dominant. This may simply reflect the fact that most (27 of 34) of the grains that were earlier classified as pristine were minute, 15 µm grains, and thus would have been lost preferentially when the SEM mounts were prepared.

Using the SEM the primary forms of the pristine grains and also of most of the modified grains can be discerned. Some were originally crystals or equant blocks while others were leafy. Most of the pristine (Figs. 1a, b) and slightly modified (Figs. 1c, d) grains were crystals. These crystals tend to be very small and thus may owe their preservation to being liberated only during or after glacial transport rather than at their bedrock sources. As well, it is much more difficult to change the shape of a crystal than that of a leaf. Consequently, most of the moderately modified (Photos 1e, f), strongly modified (Photos 1g, h) and fully reshaped (Photos 1i, j) grains were originally leaves. One reshaped grain from Sample 406 (Photo 1j) and another from Sample 403 are intricately honeycombed, indicating post-glacial dissolution of a soluble mineral that was originally intergrown with the gold.

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The surface finenesses of the ten photographed gold grains range from 404 to 1000 (Table 2). Those of the eight pristine to modified grains span a narrower range from 681 to 1000. Such variability is common within dispersal trains, possibly because most gold grains are compositionally zoned and modification of the grains during glacial transport exposes zones having different finenesess.

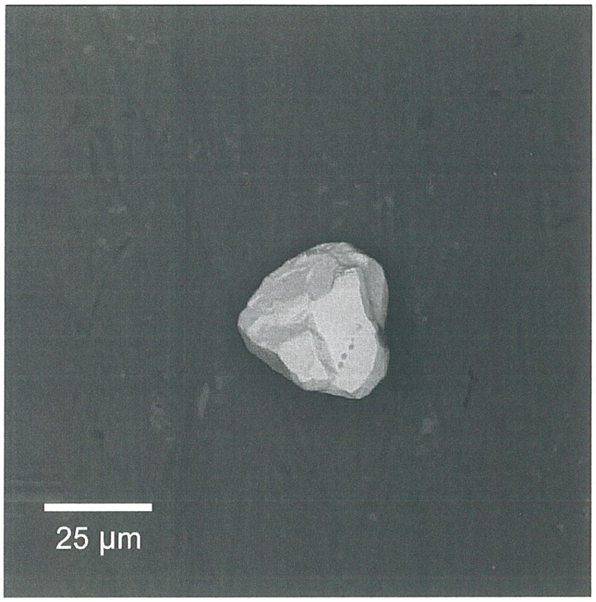
The two reshaped grains, which are evidently derived from more distal bedrock sources, have lower finenesses of 680 and 404. The very low 404 value is of particular interest because it is from the honeycombed grain. The soluble component of such grains is normally a telluride but the unusually high ~60 percent Ag content of this grain may have facilitated the formation of the observed leach structures.

In summary, our original binocular microscope descriptions of the gold grain morphologies appear to be accurate; i.e. most of the grains are pristine to modified and only a few are reshaped. Therefore a bedrock gold source (or sources) must be present within or near the surveyed area. This source may be more proximal than indicated by the ratio of pristine to modified grains determined by SEM because the pristine grains are under-represented on the SEM mounts due to the difficulty of handling such small grains.

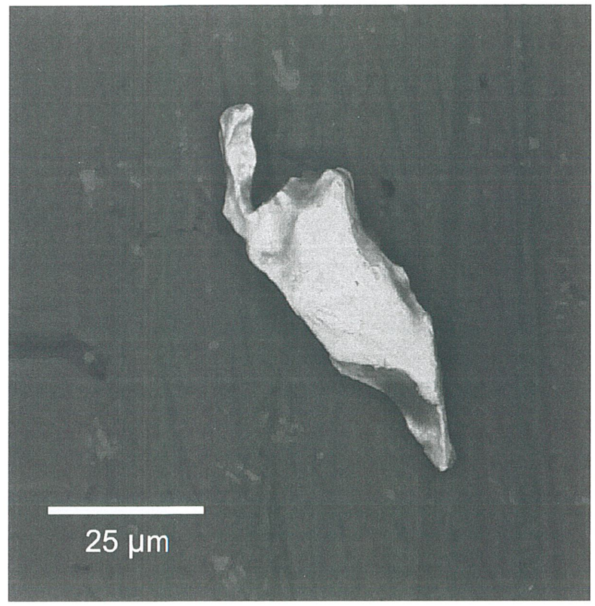
I hope these notes are helpful. Please call me if you have any questions.

Yours sincerely;

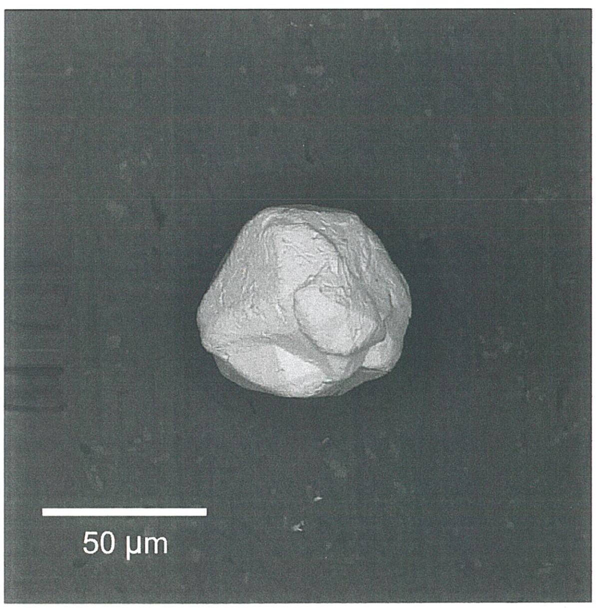
FOR Stu Averill; P.Geo.,
Chairman
cc Donald Elsenheimer



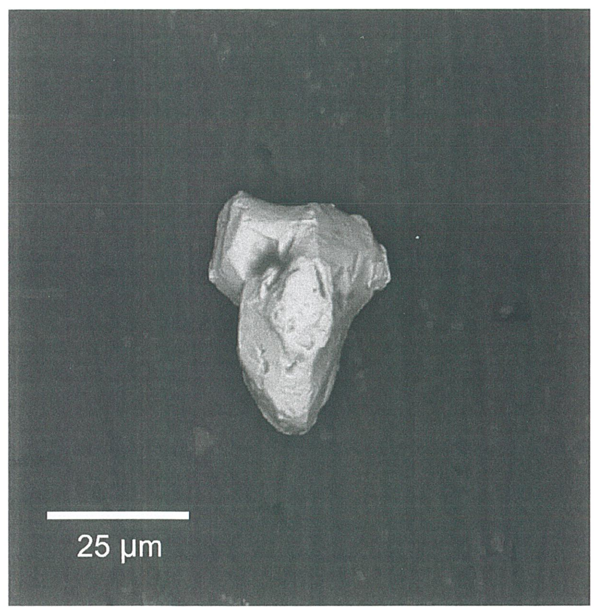
1a – Pristine crystal. Surface fineness = 783.



1b – Pristine leaf. Surface fineness = 744.

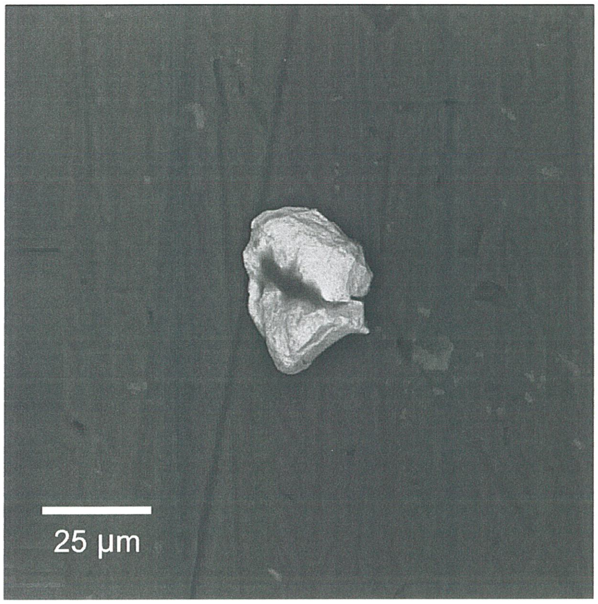


1c – Slightly modified crystal. Surface fineness = 1000.

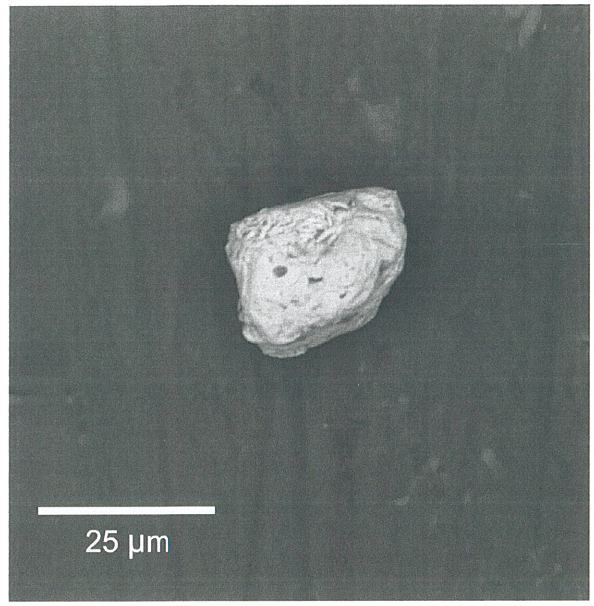


1d – Slightly modified crystal aggregate. Surface fineness = 887.

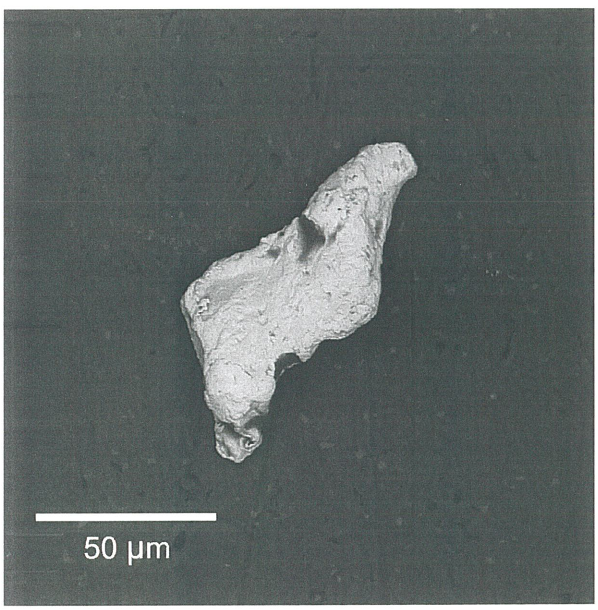
Figure 1 – Backscatter SEM images of representative grains of each morphological class from Sample 406. The surface fineness of each grain is also included. Page 1 of 3.



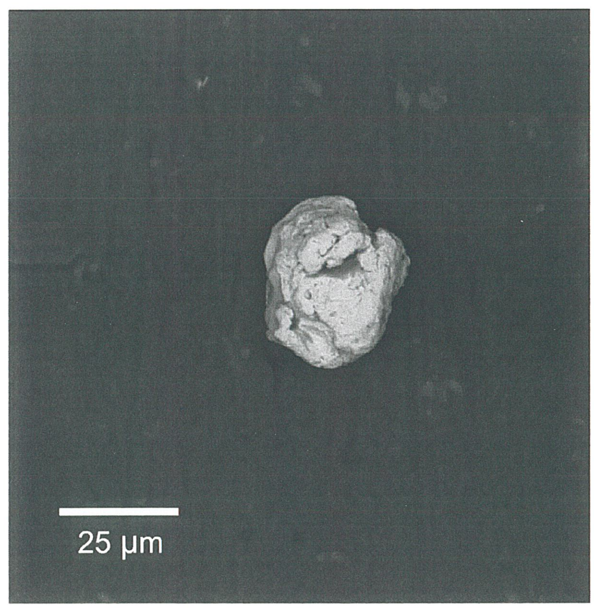
1e – Moderately modified, backfolded leaf.
Surface fineness = 784.



1f – Moderately modified blocky grain.
Surface fineness = 936.

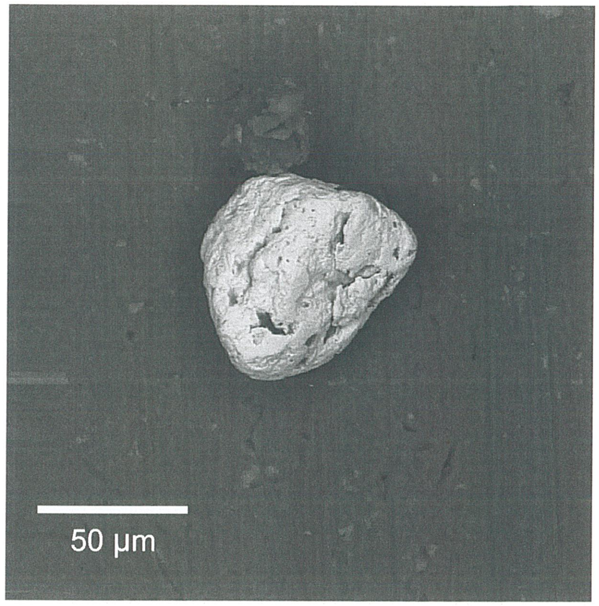


1g – Strongly modified leaf. Surface fineness = 681.

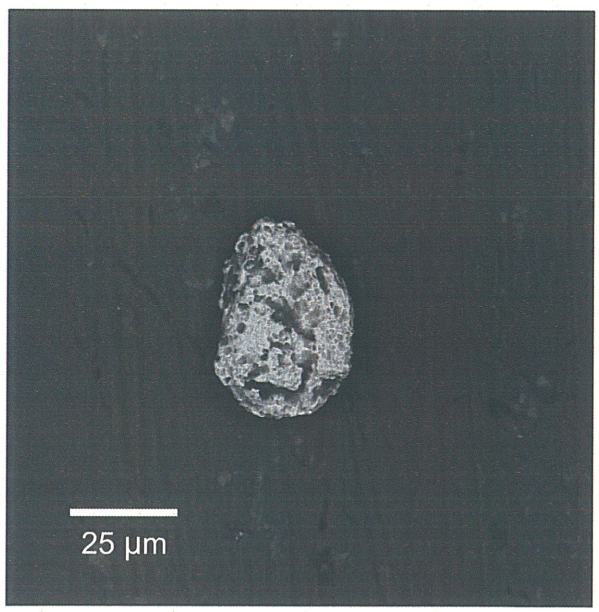


1h – Strongly modified leaf. Surface fineness = 981.

Figure 1 – Backscatter SEM images of representative grains of each morphological class from Sample 406. The surface fineness of each grain is also included. Page 2 of 3.



1i – Fully reshaped grain. Surface fineness = 680.



1j – Reshaped grain honeycombed by post-glacial leaching of a soluble intergrown mineral, probably a telluride. Surface fineness = 404.

Figure 1 – Backscatter SEM images of representative grains of each morphological class from Sample 406. The surface fineness of each grain is also included. Page 3 of 3.

	Number of Gold Grains by Morphology										
	Binocular Microscope				SEM						
							Modified				
Sample No.	Total	Reshaped	Modified	Pristine	Total	Reshaped	Total	Strongly	Moderately	Slightly	Pristine
CATS-403	66	10	27	29	10	7	3	2	1	0	0
CATS-406	56	8	14	34	25	7	15	7	3	5	3
CATS-416	49	16	22	11	22	4	17	8	5	4	1

Table 1 – Comparative morphological classifications by binocular microscope and SEM for the gold grains from each examined sample. Less than half of the grains were mounted successfully for SEM examination.

Sample No.	Grain No.	Photo No.	Morphology	Fineness
CATS-406	24	1a	Pristine	783
CATS-406	08	1b	Pristine	744
CATS-406	06	1c	Slightly modified	1000
CATS-406	15	1d	Slightly modified	887
CATS-406	16	1e	Moderately modified	784
CATS-406	13	1f	Moderately modified	936
CATS-406	03	1g	Strongly modified	681
CATS-406	23	1h	Strongly modified	981
CATS-406	05	1i	Reshaped	680
CATS-406	25	1j	Reshaped	404

Table 2 - Summary of photographed gold grains from Sample 406.