DETECTION OF CM SIZED SPHEROIDAL FE - MN BODIES IN RHYOLITE FROM LAKE MIEN, AN IMPACT SITE IN SOUTHERN SWEDEN:
A PRELIMINARY REPORT

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Lake Mien is situated in the southern part of Sweden, 14° 52' E. long., 56° 25' N. lat. It has a diameter of slightly over 4 kilometers, and has for a long time been known for its occurrences of a rhyolitic rock known as Mien-ryolite, outcropping under the glacial deposits at the Ramsö island. Both endogenic and impact generated origins of the rhyolite have been proposed. However, since the finding of coesite by Svensson and Wickman (1965), the lake is now considered to be impact generated. First to describe the rhyolitic melt rock was Holst (1890). Later Högbom (1910) suggested that the rhyolite might be of impact origin. Several other authors have described the rhyolite from a petrographical and geochemical aspect. The most extensive work has been made by Stanfors (1973). Carstens (1975) has described the thermal history of the impact melt rock. According to him, the Mien-ryolite has been heated to a peak temperature between 1700° to 1800° C. This is indicated by the abundance of sanidine and cristoballite crystals. Quarz with "ballenl" structures also occurs. As a complement to the above referenced work, we here present preliminary results of a further study of the filled vesicles mentioned by Stanfors (1973).

General description and occurrence: The present Mien-ryolite (typeA), differ from the other types mainly by the occurrence of numerous vesicles scattered throughout the melt rock. Some of these vesicles are filled or partly filled with something looking like droplets made of iron. The filled vesicles themselves differ somewhat from each other in occurrence. The smaller ones, with a size of up to 1 cm, are usually entirely filled and look like solidified iron droplets in the melt rock. Larger ones, with a size of up to 2 - 3 cm, generally show a more complicated structure. Usually they have a central part of transparent crystals, formed as spherical knobs (buttons). These knobs are surrounded by an ironlike coating about 1 mm thick. Intermediate sizes show a dendritic or net structure of iron-like material, which are grown from a spheroidal form into the vesicle. Usually the dendritic needle like iron crystals are intergrown with transparent crystals. Other vesicles are empty but show a sub-millimeter needle like white and green coating on its walls.

Since there exist no outcrops of Mien-ryolite, only rock samples taken from the glacial deposits are available. Unfortunately this has a severe consequence on the possibility of getting unweathered rock samples for analysis. The samples for this study were mainly taken on Ramsö island where they are easiest to find. One sample was also taken just south of Lake Mien (sample no:3).

X-ray measurements: So far only two samples have been examined with X-ray diffractometer and X-ray fluorescence measurements. The same samples were used with both X-ray methods. Sample no:1 contained a light brown powder from an intermediet size vesicle filling with transparent crystals intergrown together with the ironlike material. Sample no:2 contained a dark brown to black powder from the ironlike coating in the larger type of vesicle. But unfortunately this sample was very weathered. No unweathered sample of the ironlike material has been available so far.

Diffractometer measurements: The diffractogram taken on sample no:1 shows distinct peaks for siderite. For sample no:2 the diffractogram shows distinct peaks for goethite. This means that highly oxidized iron phases form the main part of sample no:2. An investigation of minor phases in the two samples require further measurements.

Fluorescence measurements: Since uncertainties exist for, i.e. the right percentages of the matrix elements H, C and O, only relative abundancies and a comparison of the samples are of interest. Masking of several elements due to the extremely strong response from Fe also caused problems. However both sample no:1 and sample no:2 show a very similar pattern, even though differences do exist. It is noteworthy that the main constituents for both samples are Fe and Mn, with Mn/Fe 0.1. Also about 50 % of the samples contain Fe. Interesting to note is also the very low Ni/Co ratio. This is caused by the very high Co values compared to quite normal Ni values. However, for both the Ni and Co values there exist such a great uncertainty that in fact the Ni/Co can be quite normal for both samples. Further measurements will deal with this question. There also exist about 2.5 times more S in sample no:2 compared to sample no:1. But as in the case of Ni and Co, the S values are also very uncertain. As expected, sample no:1 contains more Ca than sample no:2, even though the Ca value for sample no:1 is just below one percent. This means that the amount of Ca in sample no:2 is 15 times that of sample no:1. The values for Cu and Zn is also 2 to 3 times higher in sample no:2 compared to sample no:1.

See Table 1 for details.
FE-MN BODIES IN RHYOLITE FROM LAKE MIEN

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<table>
<thead>
<tr>
<th>Element</th>
<th>Sample no:1</th>
<th>Error (%)</th>
<th>Sample no:2</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn</td>
<td>5.5 %</td>
<td>0.3</td>
<td>4.7 %</td>
<td>0.2</td>
</tr>
<tr>
<td>Fe</td>
<td>49.3 %</td>
<td>0.1</td>
<td>50.6 %</td>
<td>0.6</td>
</tr>
<tr>
<td>Mn/Fe</td>
<td>0.11</td>
<td></td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.9 %</td>
<td>44.9</td>
<td>2.2 %</td>
<td>32.6</td>
</tr>
<tr>
<td>Ca</td>
<td>0.7 %</td>
<td>2.8</td>
<td>0.05 %</td>
<td>-</td>
</tr>
<tr>
<td>Co</td>
<td>4473 ppm</td>
<td>0.8</td>
<td>4579 ppm</td>
<td>0.6</td>
</tr>
<tr>
<td>Ni</td>
<td>20 ppm</td>
<td></td>
<td>271 ppm</td>
<td>4.1</td>
</tr>
<tr>
<td>Ni/Co</td>
<td>0.004</td>
<td></td>
<td>0.059</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>47 ppm</td>
<td>7.5</td>
<td>81 ppm</td>
<td>6.1</td>
</tr>
<tr>
<td>Zn</td>
<td>40 ppm</td>
<td>6.9</td>
<td>129 ppm</td>
<td>3.4</td>
</tr>
</tbody>
</table>

TABLE: 1. Element data from the XRF measurements.

SIMS measurements: SIMS investigation has so far been carried out on one sample (sample no:3), consisting of a rhyolite matrix with an elongated Fe, Mn rich inclusion. Mass spectra and secondary ion images showed that the Fe and Mn was preferently enriched in two separate phases within the inclusion. Trace elements also showed a tendency to be enriched in the Mn rich phase. The phases are thought to be a Mn-oxide and an Fe-carbonate. Among the trace elements REE, Ba, Sr, Ti, Sr, Ba, K, Al, Na, and Mg was found. A single mass spectra taken from the X-ray sample no:1, shown to be mainly siderite, shows good agreement with the XRF measurements with the addition of trace levels of Ba, REE, Mg, Al, Si, P and S.

Discussion: Together with the data from other works (see reference list) our data indicate that at least one part of the rhyolitic impact melt rocks in Lake Mien have been heated to high temperatures 1700°-1800°C. Also this type of rhyolite have been rich in volatiles probably consisting of H₂O, CO, CO₂, together with Fe and Mn in some form. This is indicated by serpentinite and talc occurring as coatings on the walls of empty vesicles, together with the filled Fe, Mn rich vesicles. But we must have in mind that our data also indicates that the mineralisations of the Fe and Mn rich minerals are of a secondary formation. This means that the minerals formed and crystallized after the melt had cooled and solidified.

Most unsatisfactory to our work and data, is the lack of unwethered rock-samples for analysis. Wethering has most likely caused different kinds of recrystallisation. This is indicated from among other things the finding of goethite in one of the X-ray spectras.

The indication from XRF and SIMS measurements of the very high content of Fe, to high to completely solidify. This means that the minerals formed and crystallized after the melt had cooled and solidified.

What can be the cause of the fillings in the vesicles and the vesicles themselves? Three possibilities exist. The first one is that the impact was taken place into a thick Cretaceous swamp as suggested by Wickman (1987). The second possibility as proposed by Chao (1974), due to the large volume of the impact melt layer, is that the impact was trigging an endogene magma process. The third possibility, as here proposed by one of us (Ekelund), is that the impact may have been caused by a comet. The reason for this is mainly the chemical composition of the cometar nuclei. Although the complete chemical composition of comets still are poorly understood, all the important chemical elements in a cometar nuclei Delsemme, (1982) is in good agreement with the vesicles and there fillings in the Mien rhyolitic impact melt rock.

Further analysis (e.g. isotopic analysis) of preferably unwethered samples can give a clue to the answer of the origin of the vesicle inclusions.

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