Textural Evolution of S-type Micrometeorites

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Supplementary material

Supplementary Table 1

This table presents the liquidus temperatures (°C) of residual micrometeoroid melts formed after atmospheric heating and ablation under various entry conditions. These conditions include entry angle (zenith angle), entry velocity, precursor composition, and size. The residual melt composition was determined by simulating the CABMOD model with these variable entry conditions. CABMOD data for this study was obtained from Rudraswami et al. (2015, 2016, 2022). The liquidus temperature of the residual melt was calculated using the MELT software. ("na" in this table indicates entry conditions where either ablation exceeds 90 %, making survival and spherule formation unlikely, or composition is enriched in Ca, Al and Ti, leading to the formation of CAT spherules instead of S-type cosmic spherules)

(a) Liquidus Temperatures (°C) of Residual Micrometeoroids melt Under Varying Entry Conditions and With CI Chondrite Precursor Compositions

Entry Velocity	Size (um)	ZA=0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
11 Km/Sec	100	1606	1606	1607	1607	1607	1607	1607	1607	1607	1607
	200	1610	1609	1608	1607	1607	1607	1607	1607	1607	1607
	300	1639	1637	1630	1622	1621	1610	1608	1607	1607	1607
	400	1704	1701	1689	1670	1647	1627	1612	1607	1607	1607
	500	1740	1737	1723	1701	1673	1641	1618	1607	1607	1607
	600	na	na	na	1761	1738	1694	1646	1607	1607	1607
	700	na	na	na	na	1778	1735	1675	1607	1607	1607
16 Km/Sec	100	1656	1652	1642	1629	1619	1611	1609	1608	1607	1607
	200	na	na	na	na	na	1741	1667	1616	1607	1607
	300	na	na	na	na	na	na	na	1699	1607	1607
	400	na	na	na	na	na	na	na	na	1607	1607
	500	na	na	na	na	na	na	na	na	1607	1607
	600	na	na	na	na	na	na	na	na	1607	1607
	700	na	na	na	na	na	na	na	na	1607	1607

(b) Liquidus Temperatures (°C) of Residual Micrometeoroids melt Under Varying Entry Conditions and With CV Chondrite Precursor Compositions

Entry Velocity	Size (um)	ZA=0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
11 Km/Sec	100	1614	1612	1611	1610	1609	1608	1607	1607	1606	1606
	200	1643	1642	1636	1629	1620	1615	1611	1608	1606	1606
	300	na	na	na	na	1689	1655	1627	1612	1608	1606
	400	na	na	na	na	na	na	1668	1625	1612	1606
	500	na	na	na	na	na	na	na	1661	1616	1606
	600	na	na	na	na	na	na	na	1692	1620	1606
	700	na	na	na	na	na	na	na	na	1636	1606
16 Km/Sec	100	na	na	na	na	na	1694	1641	1613	1608	1606
	200	na	na	na	na	na	na	na	1685	1616	1606
	300	na	na	na	na	na	na	na	na	1659	1606
	400	na	na	na	na	na	na	na	na	na	1606
	500	na	na	na	na	na	na	na	na	na	1606
	600	na	na	na	na	na	na	na	na	na	1606
	700	na	na	na	na	na	na	na	na	na	1606

(c) Liquidus Temperatures (°C) of Residual Micrometeoroids Under Varying Entry Conditions and With CM Chondrite Precursor Compositions

Entry Velocity	Size (um)	ZA=0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
11 Km/Sec	100	1602	1602	1599	1599	1599	1600	1600	1600	1600	1600
	200	1614	1611	1608	1606	1603	1603	1602	1599	1600	1600
	300	1682	1678	1667	1650	1631	1615	1604	1602	1601	1600
	400	na	1758	1746	1726	1694	1654	1621	1604	1602	1600
	500	na	na	na	na	na	1751	1690	1626	1603	1600
	600	na	na	na	na	na	na	1730	1649	1604	1600
	700	na	na	na	na	na	na	1758	1672	1607	1600
16 Km/Sec	100	1701	1695	1681	1660	1634	1614	1604	1602	1600	1600
	200	na	na	na	na	na	na	1728	1633	1603	1600
	300	na	na	na	na	na	na	na	1747	1612	1600
	400	na	na	na	na	na	na	na	na	1659	1600
	500	na	na	na	na	na	na	na	na	na	1600
	600	na	na	na	na	na	na	na	na	na	1600
	700	na	na	na	na	na	na	na	na	na	1600

(d) Liquidus Temperatures (°C) of Residual Micrometeoroids Under Varying Entry Conditions and With LL Chondrite Precursor Compositions

Entry Velocity	Size (um)	ZA=0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
11 Km/Sec	100	1594	1593	1593	1592	1590	1589	1589	1588	1588	1588
	200	1722	1718	1704	1681	1653	1618	1597	1591	1588	1588
	300	na	1803	1794	1776	1745	1696	1640	1592	1589	1588
	400	na	na	na	na	na	1769	1703	1628	1593	1588
	500	na	na	na	na	na	na	1775	1682	1602	1588
	600	na	na	na	na	na	na	na	1756	1629	1588
	700	na	na	na	na	na	na	na	1793	1659	1588
16 Km/Sec	100	na	na	na	na	1783	1733	1656	1601	1590	1588
	200	na	na	na	na	na	na	na	1791	1626	1588
	300	na	na	na	na	na	na	na	na	1711	1588
	400	na	na	na	na	na	na	na	na	1785	1588
	500	na	na	na	na	na	na	na	na	na	1588
	600	na	na	na	na	na	na	na	na	na	1588
	700	na	na	na	na	na	na	na	na	na	1588

(e) Liquidus Temperatures (°C) of Residual Micrometeoroids Under Varying Entry Conditions and With L Chondrite Precursor Compositions

Entry Velocity	Size (um)	ZA=0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
11 Km/Sec	100	1570	1569	1568	1567	1566	1565	1564	1564	1564	1564
	200	1714	1710	1695	1670	1638	1604	1579	1566	1564	1564
	300	na	na	1789	1770	1738	1686	1623	1579	1566	1564
	400	na	na	na	na	na	1765	1693	1608	1567	1564
	500	na	na	na	na	na	na	1771	1671	1578	1564
	600	na	na	na	na	na	na	na	1752	1609	1564
	700	na	na	na	na	na	na	na	1794	1645	1564
16 Km/Sec	100	na	na	na	na	1782	1728	1641	1578	1565	1564
	200	na	na	na	na	na	na	na	na	1607	1564
	300	na	na	na	na	na	na	na	na	1706	1564
	400	na	na	na	na	na	na	na	na	na	1564
	500	na	na	na	na	na	na	na	na	na	1564
	600	na	na	na	na	na	na	na	na	na	1564
	700	na	na	na	na	na	na	na	na	na	1564

(f) Liquidus Temperatures (°C) of Residual Micrometeoroids Under Varying Entry Conditions and With H Chondrite Precursor Compositions

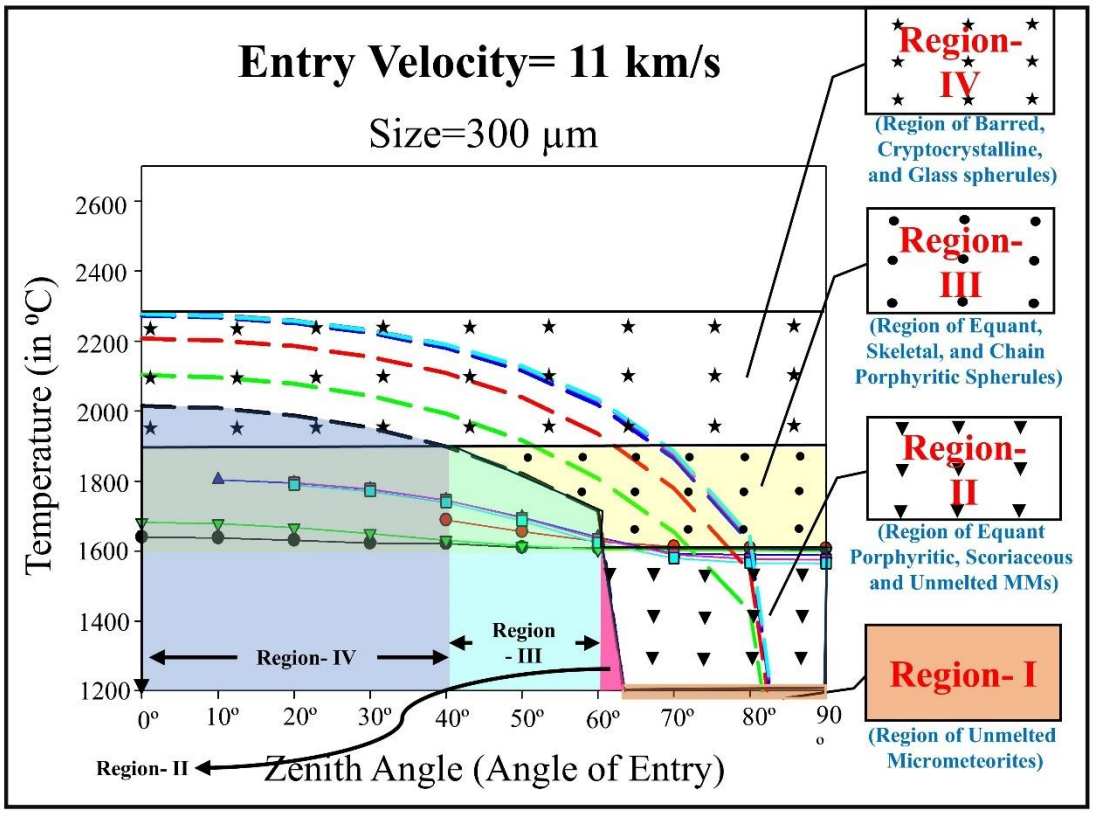
Entry Velocity	**Size (um)**	**ZA=0°**	**10°**	**20°**	**30°**	**40°**	**50°**	**60°**	**70°**	**80°**	**90°**
11 Km/Sec	**100**	1582	1581	1580	1579	1577	1576	1575	1575	1575	1575
	200	1722	1717	1703	1679	1649	1615	1590	1577	1575	1575
	300	na	na	1795	1777	1745	1694	1634	1590	1577	1575
	400	na	na	na	na	na	1770	1701	1620	1580	1575
	500	na	na	na	na	na	na	1776	1680	1590	1575
	600	na	na	na	na	na	na	na	1758	1621	1575
	700	na	na	na	na	na	na	na	1794	1655	1575
16 Km/Sec	**100**	na	na	na	na	na	1734	1589	1582	1575	1575
	200	na	na	na	na	na	na	na	na	1617	1575
	300	na	na	na	na	na	na	na	na	1714	1575
	400	na	na	na	na	na	na	na	na	na	1575
	500	na	na	na	na	na	na	na	na	na	1575
	600	na	na	na	na	na	na	na	na	na	1575
	700	na	na	na	na	na	na	na	na	na	1575

Supplementary Figure 1.

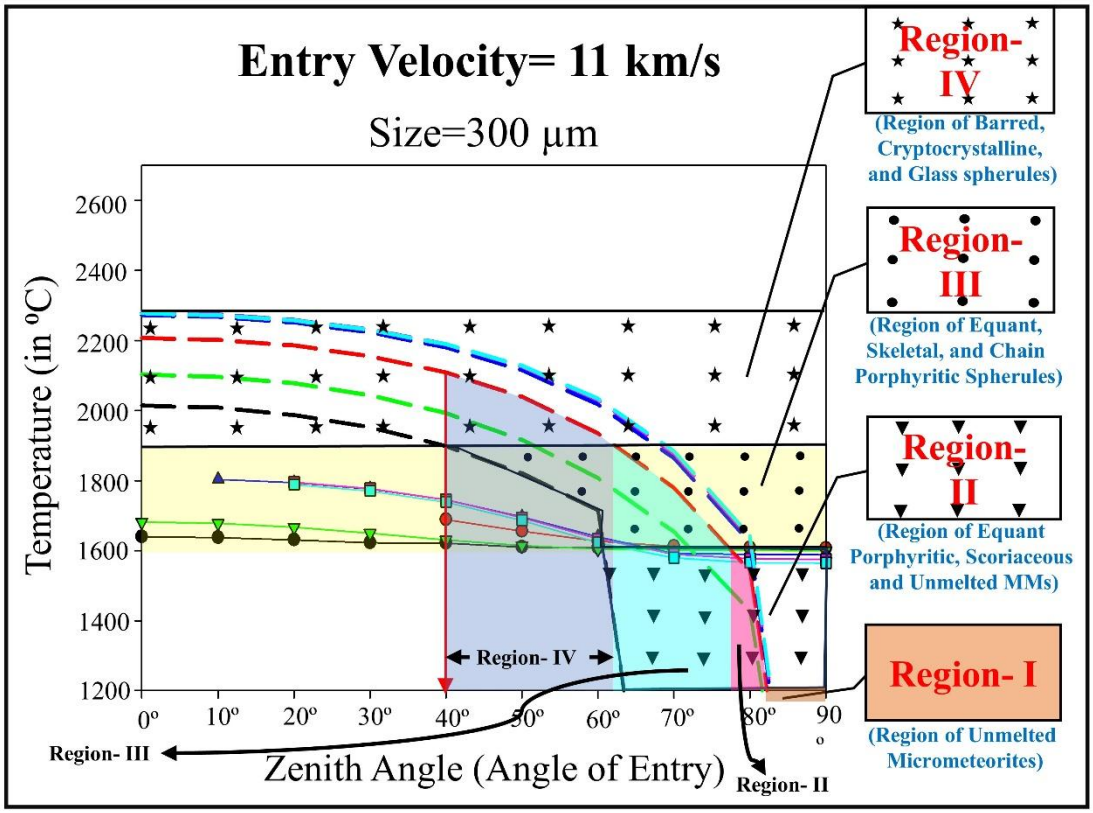
This figure illustrates the range of entry angles that defines the extent of the various regions (i.e., the width of each region) described in Figure 10 for CI, CV, and LL types of precursor materials. Similarly, for other types of precursor materials, the entry angle ranges that support all four regions can also be determined. Thus, for Figures 8 and 9, the entry angle ranges supportive of the four distinct regions can be identified. This allows us to ascertain the combination of atmospheric entry parameters conducive to the development of different types of micrometeorites. The legends of this Figure are similar to those in Figures 8 and 9.

- The brown shaded area signifies the angular extent for Region I (Heating temperature < 1200º C).
- The pink shaded area denotes the angular extent for Region II (Heating temperature > 1200º C and less than Chondritic olivine liquidus temperature (precursor)).
- The cyan shaded area indicates the angular extent for Region III (Heating temperature overlaps the Chondritic olivine liquidus temperature).
- The blue shaded area illustrates the angular extent for Region IV, defined by heating temperatures that exceed the precursor liquidus temperature but remain below the threshold where ablation and evaporation surpass 90%. This is indicated by the inverted vertical arrow, which marks the highest temperature up to which residual melt liquidus can be attained.

A) Illustration of angular extent for all four regions for CI precursor.



B) Illustration of angular extent for all four regions for CV precursor.



C) Illustration of angular extent for all four regions for LL precursor.