Morphology of impact glass ejecta associated with the Chicxulub asteroid impact: New data from Gorgonilla Island, Colombian Pacific

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Material is scarce and not always well preserved
Millions of exquisitely preserved microtektites (90% pure glass)
Most pristine K/Pg boundary spherule-rich layer known to date
Gorgonilla Island
- Gorgona National Natural Park
~20 miles off the Colombian coast
KPB ~3000 km Chicxulub

Location
2-cm-thick spherule-rich bed

KPB interbedded ultramafic lavas and deep-sea marine deposits

$^{40}\text{Ar}/^{39}\text{Ar}$ dating and planktic foraminiferal - Chicxulub

Age of 66.051 ± 0.031 Ma

Suggested age impact (66.052 ± 0.043 Ma)
Material & Methods

Gorgonilla Island K/Pg spherule-rich layer

Manual disgregation

Olympus VT-II Stereo Microscope - Zeiss Stemi 508 with axiocam

1000 individual spherules (significant quantity - statistically representative)

New model based on Stauffer & Butler, 2010

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Material

Sampling

Selection & counting

1000 spherules

Classification / Interpretation
GROUP I
Spin or modified spin-induced forms

GROUP II
Muong Nong-type tektites (layered tektites)

Group I: 100%
Group II: 0%
<table>
<thead>
<tr>
<th>Spin or modified spin-induced forms</th>
<th>GROUP I</th>
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</thead>
<tbody>
<tr>
<td>Splash-form tektites</td>
<td></td>
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<tr>
<td>Spheres</td>
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<tr>
<td>Rods</td>
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<td>Ovoids</td>
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<td>Ovoid Disks</td>
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<td>Spherical Disks</td>
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<td>Dumbbells</td>
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<td>Bowties</td>
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<td>Oval Bowls</td>
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<td>Tear Drops</td>
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<td>Teardrop Bars</td>
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<td>Ovoid Teardrops</td>
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<tr>
<td>Teardrop Disks</td>
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<tr>
<td>Fused-form tektites</td>
<td>Any combination of 2 or more splash-form tektites</td>
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<tr>
<td>Deformed tektites</td>
<td>Any splash-form tektite with evidence of deformation (by rotation or impact)</td>
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<tr>
<td>Irregular tektites</td>
<td>Undefined morphologies including impact effects</td>
</tr>
<tr>
<td>Ablation-form tektites</td>
<td>Not present</td>
</tr>
</tbody>
</table>

1 mm
Deformed-form: 2%
Fused-form: 3%
Irregular-form: 1%
Ablation-form: 0%
Splash-form: 94%
Splash forms, other morphologies variations or combinations of splash forms

Modified version Stauffer and Buttler (2010)

Provides us quantitative way to study the shapes of splash-form tektites

Using these diagnostics, we can give quantitative definitions and try to understand the origin of this shapes based on basic physics
Major axis is the length (L)
Intermediate axis is the width (W)
Minor axis is the thickness (T)
Using these values, we can define different shapes and different degrees of flattening and elongation.

Quadrangles have been modified to radial quadrangles and integrated into a single classification scheme.
Different morphologies that result from deforming at different rates an original sphere. Progressive deformation, depending on the shape, results in different degrees of flattening or elongation.
Simplified diagram

Shapes and degree of flattening or elongation in a descriptive way
Chicxulub ejecta in Gorgonilla

- **Spheres**: 42%
- **Ovoids**: 35%
- **Rods**: 2%
- **Ovoid Disks**: 1%
- **Spherical Disks**: 2%
- **Dumbbells**: 2%
- **Bowties**: 1%
- **Oval Bowls**: 2%
- **Circular Bowls**: 2%
- **Teardrop Bars**: 2%
- **Tear Drops**: 3%
- **Ovoid Teardrops**: 1%
- **Teardrop Disks**: 2%
- **Deformed-form**: 2%
- **Fused-form**: 3%
- **Irregular-form**: 1%

Vast majority (almost 80%) are spheres or ovoids. Why?
Tektite forms are transitional, beginning spherical that deforms through viscous fluid flow processes into other shapes depending rotational velocity and perhaps, if still sufficiently fluid, back to a sphere.

Material inside a tektite liquid, but as it cools, continuing to deform until it either becomes too stiff, ceases to spin, or lands.
Travelling time

+ Collision = Fused-form tektites

Sphere + Spinning = Splash-form tektites + Spinning = Deformed tektites + Spinning = Sphere

+ Impact = Irregular tektites

Cooling time
Superheated plasma in excess of 10,000°C
Some shocked basement rocks remain in the cloud as it travels away from Chicxulub.

20 minutes after impact the cloud reaches Gorgonilla.

Artemieva & Morgan, 2020
Discussion and conclusions

First approximation to the mechanisms involved in the formation of the microtektites produced by the Chicxulub

Splash-form tektites/microtektites = Melt droplets - Ballistic trajectories

Several splash-forms + Fused forms + Deformed forms = Enough time to reach different stages

Microkrystites (~ 16%) = Condensed spherules from vapor plume

Mainly spheres and ovoids

Splash – fused – deformed – irregular-forms

Bermudez & Cui, 2020
100% spherules correspond to spin or spin-induced forms – No ablation-forms

The spin-induced spherule morphology: I) Splash-forms; II) Fused-forms; III) Deformed-forms IV) Irregular forms

The large % of spherical shapes - long ballistic trajectories or condensation

Condensed spherules (spheres + ovoids) = Small size (lower bond numbers); gravity – no rotation and/or shorter evolution time
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