trees taken from higher latitudes, e.g. Wisconsin (lat. \( \sim 45^\circ \) N) trees have average \( \delta^{18}O \) value of about 26\% and British Columbia (lat. \( \sim 55^\circ \) N) trees have average value of about 23\% (ref. 13). Therefore the enriched value of \( \delta^{18}O \) ratio in air \( CO_2 \) from Ahmedabad can probably be ascribed to equilibration of \( CO_2 \) with enriched leaf water expected in the tropical part of India. The enrichment in \( CO_2 \) is less than that of the leaf water due to the rapid mixing of air on a global scale.


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Precambrian–Cambrian boundary in the Tal Formation of Garhwal Lesser Himalaya: Rb–Sr age evidence from black shales underlying phosphorites

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The recently reported faunal evidence for placing the Precambrian–Cambrian boundary within the main phosphorite unit of the Chert–Phosphorite Member of the Tal Formation, Garhwal Lesser Himalaya, is supported by the present report of 626 ± 13 myr for the whole-rock Rb–Sr isochron age of the black shales directly underlying the phosphorite band.
available data show a large spread from 530 to 620 myr (million year) depending on geographical location, material dated and geochronological techniques used. Consistent ages for the Meishucunian boundary have been inferred from the whole-rock Rb-Sr dating of black shales deposited shortly after the boundary units. We have therefore dated the black shales immediately underlying the phosphorite band of the lower Tal Formation to infer the age of this proposed boundary unit.

The basis for Rb-Sr dating fine-grained sedimentary rocks like black shales is that they were isotopically equilibrated with sea water during their sedimentation or early diagenesis and remained closed to Rb and Sr exchange since then. The black shales in the present study consist primarily of illite, organic carbon, carbonates and some detrital quartz. A closer examination of the X-ray diffractogram of the separated fine fraction ~ 2 μm shows the illite to be sedimentary, I M polytype with sharpness ratio (SR) or Weaver index (WI) around 2 (refs. 12, 13). The presence of fresh pyrite in these shales argues against any secondary alteration due to permeating water, and thus provided a close system.

The whole-rock samples were collected within a few metres along the strike of a 15-25-cm-thick black carbonaceous shale band. About 100 mg each of the powdered samples was dissolved in HF+HNO₃ and spiked with ⁸⁴Sr and ⁸⁷Rb tracers. The undissolved carbon was centrifuged to get a clear solution for ion-exchange separation of Rb and Sr. Rb and Sr isotopic compositions and abundances were measured on an automatic VG 354 thermal ionization mass spectrometer with the SRM 987 Sr standard giving a mean of 0.71025 ± 5. Processing contamination was negligible relative to the amount of Rb and Sr actually handled.

Rb-Sr analytical data for nine shale samples (Table 1) plotted on a Sr-evolution diagram (Figure 2) form a linear array with good mutual spread. The best-fit straight line (MSWD = 7) to the data has a slope corresponding to an age of 626 ± 13 myr and intercept on the ordinate corresponding to an initial Sr ratio of 0.7093 ± 1, the error in the age having been increased to allow for the MSWD being greater than unity. If the line is interpreted as an isochron, these results will imply that the samples have evolved from 626 myr as individually closed systems from a common initial Sr ratio of 0.7093 ± 1. This age most probably relates to the time of deposition or early diagenetic equilibration of Sr isotopes among the fine-grained silicate and carbonate components of the shale. The initial Sr ratio is quite close to that of sea water about 600 myr.

Since the proposed phosphorite boundary unit is immediately overlying the black shale, we believe that its time of deposition must be quite close to 626 myr. This agrees within error limits with the age of 610 ± 10 myr inferred for the Sinian (Precambrian)-Cambrian boundary in China. Since the latter is a mean of several measurements on shales from different sections in the Yangtze platform, but not directly in contact with the boundary unit, its agreement with our result can be considered as only general. Further analysis of shale samples, preferably separated into various fractions, will be required to reach a firmer conclusion on the age of phosphorite band. But the present result does support the faunal evidence that the basal units of the Tal Formation in Garhwal Lesser Himalaya were deposited just prior to

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**Table 1.** Rb/Sr data of black shales from the Chert-Phosphorite Member of Tal Formation, Surkhhet Block, Maldoota Phosphorite Mine, Garhwal Lesser Himalaya.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Rb (ppm)</th>
<th>Sr (ppm)</th>
<th>⁸⁷Rb/⁸⁶Sr*</th>
<th>⁸⁷Sr/⁸⁶Sr**</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-9/2</td>
<td>21.1</td>
<td>101.0</td>
<td>0.603</td>
<td>0.71398 ± 4</td>
</tr>
<tr>
<td>S-9/4</td>
<td>19.6</td>
<td>63.8</td>
<td>0.608</td>
<td>0.71016 ± 4</td>
</tr>
<tr>
<td>S-9/7</td>
<td>89.7</td>
<td>59.6</td>
<td>4.374</td>
<td>0.74837 ± 8</td>
</tr>
<tr>
<td>S-9/8</td>
<td>105.6</td>
<td>81.9</td>
<td>3.732</td>
<td>0.74337 ± 6</td>
</tr>
<tr>
<td>S-9/9</td>
<td>86.3</td>
<td>114.6</td>
<td>2.184</td>
<td>0.72937 ± 4</td>
</tr>
<tr>
<td>S-9/10</td>
<td>84.4</td>
<td>124.5</td>
<td>1.965</td>
<td>0.72700 ± 4</td>
</tr>
<tr>
<td>S-9/11</td>
<td>86.6</td>
<td>173.1</td>
<td>1.450</td>
<td>0.72279 ± 2</td>
</tr>
<tr>
<td>S-9/12</td>
<td>91.5</td>
<td>137.3</td>
<td>1.930</td>
<td>0.72653 ± 6</td>
</tr>
<tr>
<td>S-9/13</td>
<td>101.1</td>
<td>84.5</td>
<td>3.470</td>
<td>0.73962 ± 4</td>
</tr>
</tbody>
</table>

* Analytical error on ⁸⁷Rb/⁸⁶Sr is ± 2% 
** Errors are 2 standard deviations of the mean.
and during the dramatic transition from the Precambrian to the Cambrian and hence can be used to reconstruct the events during this important phase in earth history.


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Geodynamic significance of Algal-oncolites reported from Dras and Lamayuru area of the Indus-Tsangpo collision zone of Ladakh Himalaya, India

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Olistoliths, the enigmatic blocks of limestone, which for long have puzzled geoscientists, occupy the northern margin of Zanskar shelf sediments. They are observed within different tectonic zones of western Ladakh Himalaya, constituting a major part of Indus-Tsangpo Suture Zone. These olistoliths, which are often associated with fossiliferous and organosedimentary structures, i.e., spherical to elliptical oncolites, provide important clues for deciphering both the pre-collision sedimentary history of the Zanskar shelf and the collision-related tectonics of the Indus-Tsangpo Suture Zone.

The Indus-Tsangpo Suture Zone in the NW sector of the Ladakh Himalaya decipher a complete N-S cross-section of the suture zone-related rocks and their tectonic set up. Studies have demonstrated that the NW sector of the Ladakh Himalaya is sandwiched between the backthrusted Tethys Himalaya zone of the Spiti and Zanskar (Zanskar Supergroup) to the south and the Karakoram zone (Karakoram Thrust) to the north. We report here the presence of oolithic-bearing limestone olistoliths 'esotic blocks' of limestone) around Lamochun peak, south of Dras village. The limestone olistoliths are tectonically incorporated in the Dras Volcanic Formation of Cretaceous age, which is underlain by Zanskar Thrust to the south (Figure 1). These limestones, occurring as tooth-like projections, are 50–100 m thick, associated with olistoliths along with fragmentary molluscan remains with it.

The limestone olistolith within the Lamayuru Formation of Triassic-Paleogene age also exhibits oncolite association near the village Saraks, north of Namikla pass. The limestone olistoliths are tectonically juxtaposed with the Lamayuru Formation of distal turbidites of the basin plain setting. Macroscopic study reveals flattened spherical to ellipsoidal geometry of oncolite. They are often fragmented. Sometimes they show a mosaic-like pattern and often reflect the shape of the intraclastic nuclei (Figures 2, 3). Their size ranges from 0.2 cm to 4 cm (Figures 4, 5). Microscopic studies reveal that the grain-supported fabric and the dolomitized sparry calcite cement occupy the interparticle pore spaces. Some of the sections, however, show that the grains are supported by algal encrustations. Algal intraclast form the oolithic nuclei, molluscan fragments and other skeletal particles are

Figure 1. Location and index map with lithocolumn and oolite locality.