Taxonomy and Preservation of Lower Cambrian Trilobites, Carrara Formation, Southern California.

Zander Cole and Reydaliz Torres Lopez
Sponsors: Sarah Gaudio, Jacalyn Wittmer-Malinowski, D. Jeffrey Over
Department of Geological, Environmental, and Planetary Sciences

Abstract

Trilobites are an extinct group of arthropods made up of three distinct body parts produced by calcite that disarticulate after molting. Trilobites lived in shallow, tropical, marine environments and left an excellent fossil record. The Cambrian is known as the age of trilobites, with the greatest diversity of trilobite forms. However, trilobites went extinct at the end of the Permian. The Carrara Formation (lower Cambrian) in Emigrant Pass, Mojave Desert, California hosted a wide range of trilobite fossils. The area contains moderately deformed and metamorphosed siliciclastic and carbonate rocks from the lower Carrara. Trilobite samples were examined using a Zeiss Stereo microscope and identified based on their morphology. The samples were mostly incomplete with the cephalon as the most common segment found. The cephalon of the trilobites have been mildly sheared as a result of tectonic uplift and tilt making some of them difficult to identify. After examining the various traits within the Trilobite samples, we have concluded they are part of the Olenellidae family. Trilobite samples were also crushed to examine the bulk composition and mineralogy found within them by using tools like scanning electron microscope (SEM), energy dispersive spectroscopy (EDS), and x-ray diffraction (XRD). Trilobites displayed variable preservation of molds, minor original hard parts, and replacement exhibiting a red coating. XRD bulk analysis revealed a bulk mineral composition of quartz, Fe +2 bearing clinochlore, and Fe +3 bearing muscovite. Furthermore, SEM and EDS analysis revealed the red coating to be iron oxide, with traces of calcite and chlorite.

Introduction and Field Site

Emigrant Pass is located in southern California. Here the Carrara Formation is exposed and contains trilobite fossils from the lower Cambrian (Figure 1). This site is where the trilobite fossils were collected and used for this study. The fossils found were of trilobite segments such as the cephalon and the thorax. These segments were used in identifying the taxonomy of the trilobites and to determine the mineralogy of preservation.

Figure 1: Satellite view of Emigrant Pass with geologic units and the location of Emigrant Pass in CA.

Figure 2: Area of a fossil showing a red coating where the mineralogy of the fossil was replaced.

Methods

Our work focused on collecting trilobite fossils a) identifying the species of trilobite and b) identifying the bulk mineralogy of the fossils.

Trilobite Identification

- The trilobite fossils were examined and photographed using a Zeiss Stereo microscope.
- The photos were used to compare the morphology of the trilobite's segments to images and descriptions of the different species found in the Carrara Formation

Mineralogy Identification

- Bulk mineralogy was identified using an X-ray diffractometer (XRD) using standard procedure.
- Minerals found in trilobite fossils were identified using a scanning electron microscope (SEM) and energy dispersive spectrometer (EDS)
- Sample was coated in a layer of vaporized carbon, approx 20 nm thick prior to being in the SEM.

Figure 3. A partial thorax showing macropleural thoracic segments.

Figure 4. The cephalon of a trilobite showing a faint Bertillon pattern.

Results - Taxonomy

The trilobites belong to the Order Redlichiida, Suborder Olenellina, Superfamily Olenelloidea, Family Olenellidae, Subfamily Olenellinae, *Olenellus gilberti* or *O. clarki*. The trilobites exhibited the following morphology traits (Palmer et al. 1997) listed beside the taxonomic groups they belong to:

Order Redlichiida - Primitive appearance, numerous thoracic segments and pleurae with spinose tips, micropygous, large semicircular cephalon with a long well segmented glabella, genal spines connected to a tubular cephalic border and large crescentic eyes.
Suborder Olenellina - No facial sutures, deep lateral furrows on glabella, front circular glabellar lobe, wide rostral plate extends within genal angles, thorax has numerous non-fulcrate segments, narrow pygidium.
Superfamily Olenelloidea - Concave glabellar outline, enlarged anterior lobe, glabella narrowest at L2 or S1, L3 modified distally with posterolateral part bending backwards and encroaching on L2, ocular lobe only connected to posterolateral part of LA.
Family Olenellidae - Interocular area width half or less that of extraocular area, third thoracic segment slightly to strongly macropleural (Figure 3).
Subfamily Olenellinae - Glabellar furrows moderately defined, width of anterior part of L1 equal to width of occipital ring, posterior tip of ocular lobe ranging from opposite posterior part of occipital ring, posterior margin of cephalon slightly deflected forward distal to intergenal spine, distinct intergenal spine present, third thoracic segment macropleural, pleural spine not greatly elongated, many thoracic segments with a long axial spine, opisthothorax with variable number uniformly small segments bearing narrow pleurae.
Genus *Olenellus* - Faint Bertillon pattern of lirae (Figure 4), occipital ring smooth, genal spine angle opposite or posterior to L1, slender genal spine.

Results - Preservation

Trilobites displayed variable preservation of molds, minor original hard parts, and replacement exhibiting a red coating (Figure 2). XRD bulk analysis revealed a bulk mineral composition of quartz, chlorite, and msucovite.. Furthermore, SEM and EDS analysis revealed the red "mystery" mineral to be iron oxide, with large traces of calcite and chlorite.

Discussion

The trilobite fossils were collected from Emigrant Pass where the Carrara Formation is exposed. The Carrara Formation is lower Cambrian in age and is known to contain the following *Olenellus* species: *O. gilberti, O. frementi, O. clarki, O. nevadensis, O. puertoblancoensis, and O. euryparia* (Mount 1980). The species that best match the morphology of the collected trilobites are *O. gilberti and O. clarki* (Figure 5). The two species are different in that *O. gilberti* has narrower cephalic border, slightly longer preglabellar area and sagittal length, a wirelike cephalic border, generally less advanced genal spines, intergenal spines point directly posteriorly rather than posterolaterally and *O. clarki* has narrow preglabellar field, slightly advanced genal spines, ocular lobes moderately long, clearly terminating anterior to posterior border furrow and a slightly flattened moderately broad cephalic border (Palmer et al. 1979).

Figure 5. Almost complete O. gilberti or O. clarki trilobite collected from the Carrara Formation.

Conclusion

The lower Cambrian age trilobites collected from the Carrara Formation exposed at Emigrant Pass in southern California are determined to be of the species *Olenellus gilberti* and *Olenellus clarki.* The original calcite secreted by the trilobite was dissolved. Hydrothermal alteration of the clay minerals in the bulk rock allowed for the formation of the chlorite rim. Afterwards, there was a secondary calcite crystallization and iron oxide precipitate formation.

References

Gates-Rector, S.; Blanton, T. The Powder Diffraction File: A Quality Materials Characterization Database. Powder Diffr. 2021, 34 (4), 352–360. https://doi.org/10.1017/S0885715619000812.

Mount, J.D., 1980, An Early Cambrian Fauna from the Carrara Formation, Emigrant Pass, Nopah Range, Inyo County, California: A Preliminary Note: Southern California Paleontological Society Special Publications, no. 2, pp. 78-80.

Palmer, A.R, Halley, R.B., 1979, Physical Stratigraphy and Trilobite Biostratigraphy of the Carrara Formation (Lower and Middle Cambrian) in the Southern Great Basin: Geological Survey Professional Paper 1047 p.66-72.

Palmer, A.R., Repina L.N., 1997, Introduction to Subroder to Olenellina, in Kaesler, R.L. (ed), Treatise on Invertebrate Paleontology Part O Arthropoda 1 Trilobita, Revised Volume 1: Introduction, Order Agnostida, Order Redlichiida; Geological Society of America and University of Kansas, P. 405-429.

The HighScore suite, T. Degen, M. Sadki, E. Bron, U. König, G. Nénert; Powder Diffraction / Volume 29 / Supplement S2 / December 2014, pp S13-S18