In situ biomolecules and isotopic signals from Clarkia plant fossils

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Tertiary molecular paleobiology owes its rapid development to Clarkia plant fossils from which diverse ancient biomolecules have been reported. These claimed *in situ* biomolecules and compound specific isotope signals from identifiable fossils are critically reviewed; paleoclimatic signals derived from morphologically based methods and isotope approaches are compared.

Early work on the Clarkia biomolecules and biochemicals focused on flavonoids and their chemotaxonomic comparisons. Stable biomolecules such as lipids and lignin were found to be abundantly preserved but offer little taxonomic information. Recent studeis confirmed the preservation of relatively labile polysaccharides and polar compounds, but they are relatively uncommon. Three reports claimed the retrieval of ancient DNA sequences of different genes from different fossil taxa, although extensive racemization of amino acids were detected. Recent analeyses of compound specific carbon and hydrogen isotopes of *n*-alkanes and *n*-acids from several plant taxa suggest the preservation of *in situ* molecular isotope signatures, opening up a new avenue of paleophysiology and paleoenvironmental studies.

Mean annual temperature for the Clarkia area during the Miocene time is reconstructed using the nearest living relative approach, leaf physiognomy method, compound specific D/H ratio of sediment carboxylic acids, and direct measurement of D/H ratio of sediment water. Discrepancies exist among values obtained using paleobotanical and geochemical methods, and such inconsistency may be due to preservational bias of plant megafossils and mutiple origins of organic compounds that were used for isotope analysis.

Morphological, anatomical, ultrastructural and macromolecular preservation of leaves from the Miocene of Clarkia, Idaho, USA

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Leaves from Clarkia, are unusual – they have been claimed to exhibit ‘autumnal colours of red, brown and blackish green’ and to preserve labile biomarkers, ancient DNA and organelles. Leaves can be lifted intact from the rock (Smiley 1985, Golenberg 1991, pers. obs.).

Inspite of this ‘exceptional preservation’, the state of preservation of the least labile chemical entity, the leaf cuticle, has not been studied in combination with leaf morpholgy or ultrastructure. Fieldwork at Clarkia in summer 1999 revealed leaf fossils ranging from mere cuticle envelopes to opaque compressed leaves with thick internal organic material. Leaves of the conifers *Amentotaxus* & *Metasequoia* and the flowering plants *Quercus* & *Lithocarpus* reveal preservation of cuticle, leaf tissues, cells, and cell contents including ultrastructure of chloroplasts. *Amentotaxus* provides a natural experiment enabling us to link cuticle morphology and chemistry in two extreme preservation states. Cuticles of both lack ultrastructure and yield the highly aliphatic signature typical of leaf fossils. Exceptional preservation of leaf tissues, cells and organelles is not linked to exceptional chemical preservation in these fossils.

Reference

Golenberg, E.M. 1991, *Phil Trans R.Soc Lond* B, 333, 419-427. Smiley, C.J. Ed. 1985 *Late Cenozoic history of the Pacific North West*. Calif Acad Sci, San Francisco.