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## **Abstracts**

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# PALYNOSTRATIGRAPHY AND PALAEOGEOGRAPHY OF ORDOVICIAN STRATA (ABASTU AND ABARSAJ FORMATIONS) FROM THE SOUTHEASTERN CASPIAN SEA, NORTHERN IRAN

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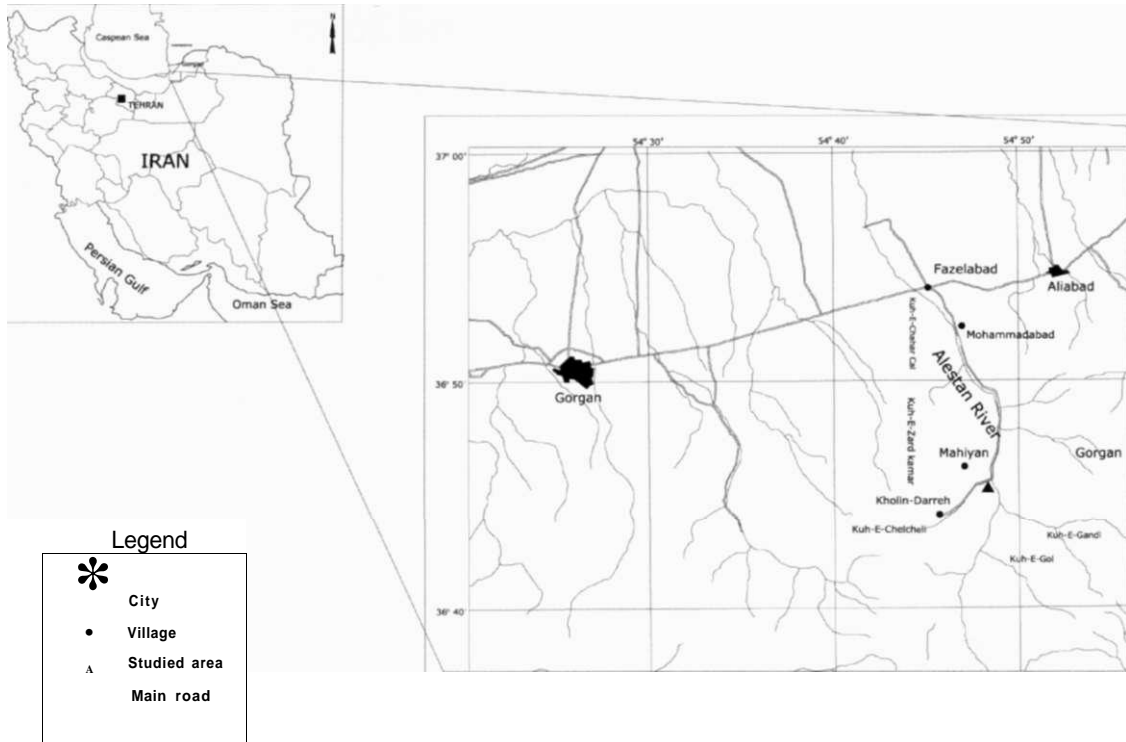
## SUMMARY

A well-preserved, abundant, and diverse assemblage of acritarchs, chitinozoans, scolecodonts, and graptolite remains was recovered from the Early Ordovician (Tremadocian) Abastu and Late Ordovician (Katian-Hirnantian) Abarsaj formations in the Alborz Mountains in Northern Iran. In the study area, 10 samples from the 108 m thick Abastu Formation yielded acritarchs indicative of an Early Ordovician (Tremadocian) age. No chitinozoans were recovered from this formation. Forty samples from the 194 m thick Abarsaj Formation yielded acritarchs and chitinozoans characteristic of a Late Ordovician (Katian-Hirnantian) age. Acritarchs from the Abastu Formation show a PeriGondwana relationship, whereas those from the Abarsaj Formation indicate a more cosmopolitan distribution. Chitinozoans from the Abarsaj Formation allow assignment to the Northern Gondwana Domain, thus demonstrating that the Alborz Mountains were clearly part of the Northern Gondwana Domain during the Ordovician. Based on the recovered palynomorph assemblage, the Abastu and Abarsaj formations were deposited in a shallow marine environment.

**Keywords:** Acritarchs, chitinozoans, Early and Late Ordovician, biostratigraphy, palaeogeography, Northern Iran

Lower Palaeozoic strata are well-exposed near Kholin-Darreh village, located 19 km south of the town of Fazelabad, and approximately 46 km southeast of the city of Gorgan. The road from Gorgan to Fazelabad-Aliabad is the principle link to the study area (Figure 1). The Palaeozoic strata are well-exposed along the Alestan River, where a secondary dirt road connects Fazelabad to Kholin-Darreh.

In this area, the Palaeozoic sequence has been divided, in ascending stratigraphic order, into the Lalun (Lower Cambrian), Abastu, Abarsaj, Negarman (Silurian), Khoshyeilagh (Upper Devonian), Mobarak (Lower Carboniferous), Qezelqaleh, Dorud (Lower Permian), Ruteh (Middle Permian) and Nessen formations (Upper Permian). Due to lack of both a diagnostic macro- and microfauna, the ages of the Lower Palaeozoic Lalun, Abastu, and Abarsaj formations have not been previously determined. However, based on palynologic evidence, two major hiatuses are indicated within the study area. The first is between the Lalun Formation (Lower Cambrian) and the Abastu Formation (Tremadocian). The second is between the Abastu Formation (Tremadocian) and the Abarsaj Formation (Katian-Hirnantian). This unconformity corresponds to the uplift related to the initial stage of rifting of the paleo Tethys Ocean.

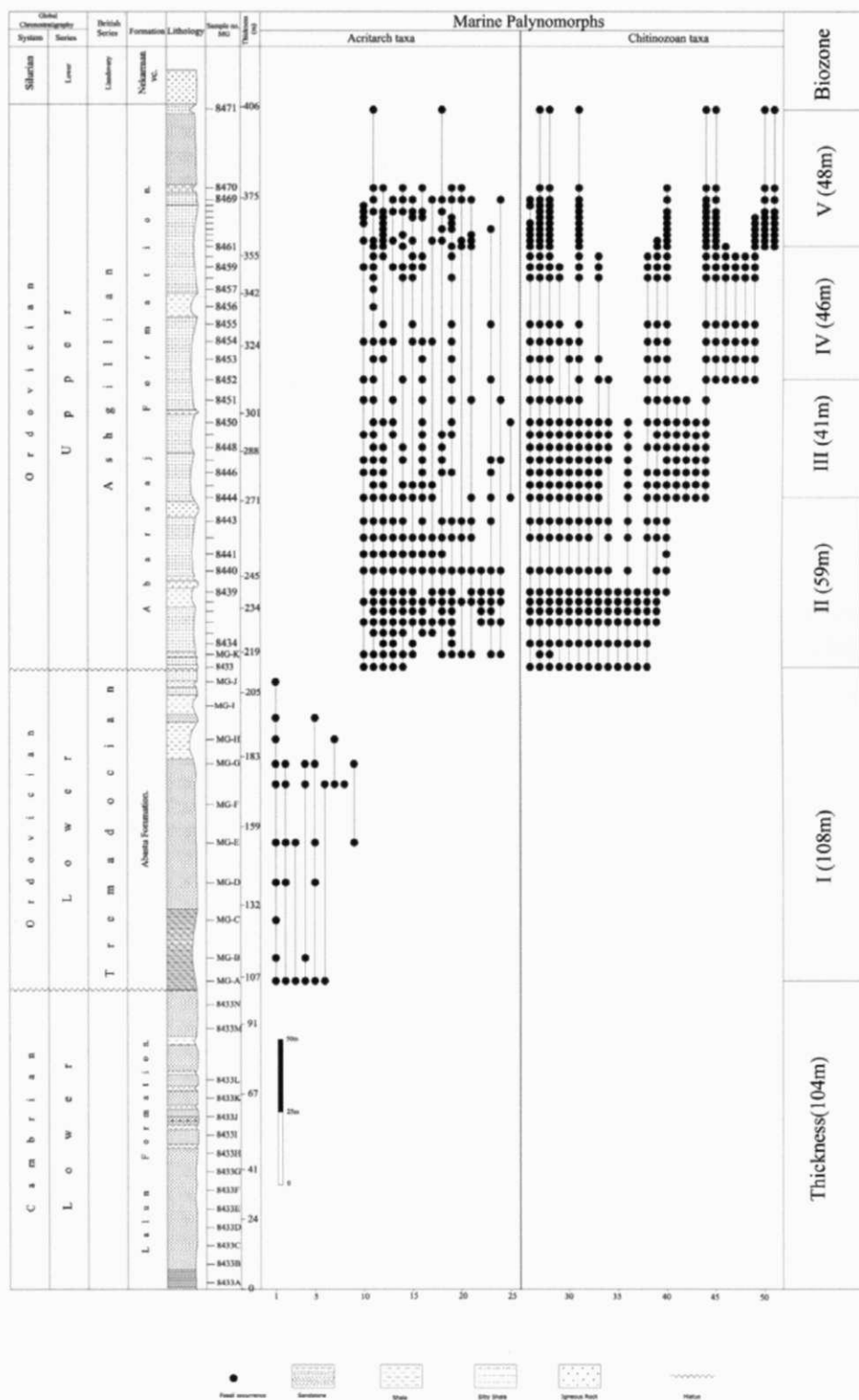


**Figure 1.** Location of the studied area.

A stratigraphic section encompassing the Lalun, Abastu and Abarsaj formations was measured and sampled for palynomorphs to determine the age of the formations, the palaeogeographic position of the Alborz Mountains in the study area, and the affiliation of the palynologic assemblage to the Gondwana and/or the Laurentian palaeoprovince.

Sixty-four samples were collected from the Lalun, Abastu, and Abarsai formations. Samples from the Lalun Formation proved to be palynologically barren, but samples from the Abastu and Abarsai formations contained a well-preserved assemblage of acritarchs, chitinozoans, scolecodonts, and graptolite remains (Figure 2).

Based on the presence of the acritarch species *Acanthodiacrodiun ubuii*, *Athabascaela penika*, *Cymatiogalea boulouardii*, *C. cylindrata*, *Dactylofusa squama*, *Michrystidium shintonensis*, *Sahardia fragilis*, *Vulcanisphaera africana* and *V. britannica* (acritarch assemblage Zone I), an age of Early Ordovician (Tremadocian) is suggested for the Abastu Formation (Figure 2). No chitinozoans were recovered from the Abastu Formation. Characteristic Late Ordovician acritarch and chitinozoan (*Ancyrochitina merga*, *Armoricochitina nigerica*, *Spinachitina oulebsiri*, and *Tanuchitina elongate*) species indicate a Katian-Hirnantian age for the Abarsaj Formation (Figure 2).



**Figure 2.** Stratigraphic distribution of selected acritarch and chitinozoan taxa from Ordovician strata near Kholin-Darreh village in the Fazelabad area, southeast of the Caspian Sea, northern Iran. Numbers refer to the corresponding columns in the figure. 1= *Sahardia fragilis*; 2=*Michrystidium shinetonensis*; 3=*Vulcanisphaera britannica*; 4=*Leiofusa squama*; 5=*Acanthodiacrodiium ubuii*; 6=*Cymatiogalea boulouardi*; 7=*Cymatiogalea cylindrata*; 8=*Athabascaella penika*; 9=*Vulcanisphaera africana*; 10=*Veryhachium lairdii*; 11=*Multiplicisphaeridium irregulare*; 12= *Veryhachium subglobosum*; 13= *Multiplicisphaeridium bifurcation*; 14= *Villosacapsula setosapellicula*; 15= *Orthosphaeridium insculptum*; 16= *Veryhachium reductum*; 17= *Actinotodissus crassus*; 18= *Ordoviciidium elegantulum*; 19= *Ordoviciidium elegantulum*; 20= *Baltisphaeridium perclarum*; 21= *Navifusa ancepsipuncta*; 22= *Dactylofusa striata*; 23=*Baltisphaeridium oligopsakium*; 24= *Orthosphaeridium ternatum*; 25=*Striathoteca principalis*; 26= *Armoricochitina nigerica*; 27=*Lagenochitina*

*baltica*; 28= *Desmochitina minor*; 29=*Armoricochitina iranica*; 30=*Armoricochitina alborzensis*; 31= *Calpichitina lenticularis*; 32= *Desmochitina juglandiformis*; 33= *Desmochitina nodosa*; 34= *Desmochitina erinacea*; 35= *Conochitina chydea*; 36= *Spinachitina bulmani*; 37= *Desmochitina cocca*; 38=*Rhabdochitina gracilis*; 39= *Cyathochitina campanulaeformis*; 40= *Lagenochitina prussica*; 41= *Ancyrochitina merga*; 42= *Plectochitina concinna*; A3=*Plectochitina sylvanica*;44= *Euconochitina lepta*; 45= *Tanuchitina elongata*; 46= *Tanuchitina sp.* ; 47= *Tanuchitina ontariensis*; 48= *Hercochitina crickmayi*; 49=*Hyalochitina sp.*; 50= *Spinachitina oulebsiri*; 51= *Spinachitina aff. oulebsiri*.

The acritarch taxa from the Abastu Formation show a PeriGondwana relationship, whereas those recovered from the Anarsaj Formation have broad similarities to those from Libya, Morocco, Algeria, Saudi Arabia, Portugal, England, the United State, and Canada, indicating a cosmopolitan nature for the acritarchs during the Late Ordovician. Chitinozoans recovered from the Abarsaj Formation allow assignment to the *Armoricochitina nigerica*, *Ancyrochitina merga*, *Tanuchitina elongata* and *Spinachitina oulebsiri* Biozones, which have been established for the Northern Gondwana Domain. These chitinozoan biozones clearly indicate that the Alborz Mountains were part of the Northern Gondwana Domain during the Ordovician. The presence of various chitinozoan and acritarch taxa from Baltica and Laurentia in Gondwanan chitinozoan biozones of the Fazelabad area suggest the existence of counter clockwise marine currents which resulted in bringing planktonic organisms (acritarchs and chitinozoans) from the lower latitudes (Baltica) to the higher latitudes (Northern Gondwana). A shallow marine environment is indicated during deposition of the Abastu and Anarsaj formations based on the recovered acritarchs, chitinozoans, scolecodonts and graptolite remains.

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