

Cathodoluminescence and Application of Elemental Criteria for the Recognition of Mixed Aragonite and Calcite Original Mineralogy in Payun Section, S.W. Iran, Zagros Basin

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Abstract

Ilam Formation (Santonian- Campanian) is a part of Bangestan Group. Petrographic and Cathodoluminescence analysis, shows marine, meteoric and burial cement in origin in Ilam Formation. Based on element and isotopical studies, mixed aragonite and calcite are the original geology in Ilam Formation. Sr/ Ca vs. Mn indicated that diagenesis occurred in semi-closed to open system. Based on the highest oxygen isotope and sea water oxygen isotope of upper Cretaceous, paleotemperature calculation indicates an ambient sea water temperature was 28° C.

Keywords: *Ilam Formation, Bangestan Group, Cathodoluminescence, , paleotemperature*

1. Introduction

Change of original carbonate mineralogy through time needs to be re-evaluated in the light of mineralogical change which is related to water temperature or latitude (e.g. Nelson, 1988; Adabi, 2004). Sr/Ca vs. Mn indicate that diagenesis occurred in open or close system. In open system, the fluid flow is high, so there is no accumulation of Sr/ Ca in the meteoric water and Sr/Ca of calcite is likely to be the same as that of the initial closed system (Kinsman and Holland, 1969). The present study uses petrographic evidence, elemental and $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values and compares these with modern tropical (aragonitic) and temperate (calcitic) carbonates and originally aragonitic Ordovician subtropical carbonates and originally calcite Permian subpolar cold-water carbonates of Tasmania, and aragonitic shallow subtropical carbonates of the Upper Jurassic Mozduran Formation of Iran to understand the original carbonate mineralogy, depositional facies and diagenetic characteristics of the Ilam Formation. In addition, the geochemical evidence was used to determine the boundary between the Ilam and Sarvak Formations, which is difficult to place due to similar lithologies in these formations (Adabi and Asadi mehmadoshti, 2008).

2. Geological setting

The study area (Payun Section) is located at 18 km of NW of Izeh, Khuzestan, Iran (Zagros Basin) (Fig. 1). Ilam Formation from Bangestan Group with Santonian to Campanian age, is consist of 147.5 meter massive, thick to thin bedded limestones. This formation is conformably overlain by Surgah and Sarvak Formations and underlain by Shales of Gurpi Formation in Payun Section. Fossils in this sections is mainly benthic foraminifera, bivalve and crinoid debris, algae and gastropods.

3. Methods of study

Samples were collected near significant lithological changes. 194 thin sections were studied for petrographic and facies analysis. Thin sections were stained by Alizarin-red S and potassium ferricyanide for distinguishing between carbonate minerals (Dickson, 1965). Forty powdered limestone samples were analysed by atomic absorption spectrometer for major elements (Ca, Mg) and trace elements (Na, Sr, Fe, Mn) at the Geology Department of Shahid Beheshti University, Tehran, Iran. Twenty six powdered samples which had previously been analysed for major and minor elements, were analysed with a Micromass, 602D for oxygen and carbon isotopes at the Central Science Laboratory, University of Tasmania, Australia. Fifteen mg of powdered samples were allowed to react with anhydrous phosphoric acid in reaction tubes under vacuum at 25 °C for 24 h. The CO₂ extract from each sample was analysed for d18O and d13C by mass spectrometry. Precision of data is $\pm 0.1\text{‰}$ for both d18O and d13C and these values were reported relative to PDB. Twenty one samples were observed with a cathodoluminescence microscope (Nikon CI, CCL 8200) at the Research Institute of Petroleum Industry (R.I.P.I).

4. Petrography

Ilam Formation in Payun Section consist of skeletal and non skeletal grains, micrite and calcite cements.

4.1. Skeletal grains

Skeletal grains consist of mainly Miliolid (benthic foraminifera) and Rudist debris. Red algae(permocalcalus), Bivalves, Crinoids, Gastropods, Sponge spicules and other benthic foraminifera such as Alveolina, Nezzazata picaroi, Textularia, Rotalia skurensis Gavarinella, Montcharmontia openinica, Cuneolina, Dicyclina, Archaecyclus, Taberina and Edomia veicheli are the other skeletal grain in Ilam Formation.

4.2. Non skeletal grains

Most of the non skeletal grains are peloids in study area. Type of peloids in Payun Section are mud peloid, fecal pellet, bahamite and microbial peloid. Intraclast, lithoclast and cortoid are the other non skeletal grains.

5. Cementation

By Petrographic and cathodoluminescence analysis, different generation of sparry calcite cement were recognized in Ilam Formation (Payun Section). This cements mainly originate in burial setting, although meteoric and marine cement were observed too. Marine cement with dull to non luminescence, mostly filled chambers of fossils or cavity wall. They commonly succeeded by equent sparry calcite cement with bright luminescence (meteoric origin), that followed by a later generation of coarsely crystalline sparry calcite cement that exhibit a dull luminescence indicating a burial origin (Fig 2).

6. Geochemistry

6.1. Major and minor elements

6.1.1 Strontium: The concentration of Sr in recent tropical carbonate sediments ranges from 8000 to 10,000 ppm (Milliman, 1974), whereas in recent temperate carbonates it ranges from 1642 to 5007 ppm (Adabi and Rao, 1991). Centralization of Sr in meteoric water is low, (subtraction coefficient less than 1), therefore, Sr increased in meteoric diagenesis trend (Adabi and Rao, 1991). In Payun section, Sr concentration varies between 483 to 1344 ppm (average 870 ppm), so low Sr quantity of Ilam carbonates can be due to meteoric diagenetic solutions. The Sr/Mn variations indicated that mixed aragonite and calcite were the original mineralogy in the Ilam Formation at Payun section (Fig. 3)

6.1.2. Manganese: In modern warm-water aragonite, Mn and Fe concentrations are less than 20 ppm (Milliman, 1974). The concentration of Mn in the Ilam limestone samples ranges from 8 to 40 ppm (average 16 ppm). Plot of Sr/Ca ratios, versus Mn values, indicative of fluence of diagenetic process in a semi-closed to open system (Fig. 4).

6.2. Carbon and oxygen isotopes: Mean $\delta^{18}\text{O}$ values for Ilam Formation are - 4.69 ‰ PDB and $\delta^{13}\text{C}$ are - 0.15 ‰ PDB. Comparison of $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ data and inverted J trend, indicate that diagenesis in Ilam Formation occurred in a meteoric system (Fig. 5).

Based on the least altered carbonate sample, the highest oxygen isotope ($\delta^{18}\text{O}$), δ_w of upper Cretaceous about -1 ‰ SMOW and using the equation of Wefer and Burger, 1991, paleotemperature calculation indicates an ambient sea water temperature was 28° C.

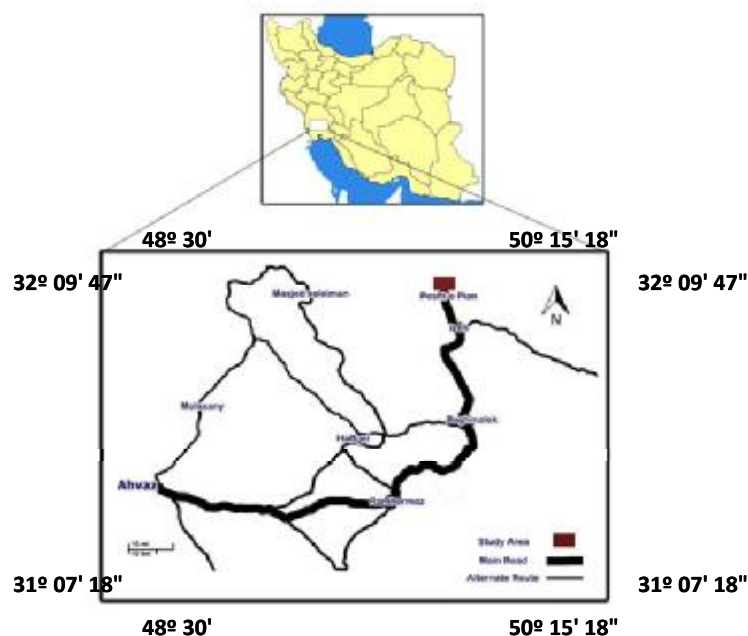


Fig. 1. Location map of the study area, Izeh, Payun Section (google map, 2010)

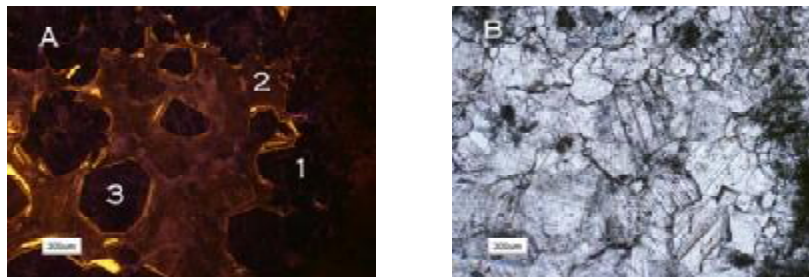


Fig. 2. Types of cement in Payun Section(A)Under cathodoluminescence, (1) First generation of cement, dull to non luminescence, marine origin, (2) Meteoric cement with bright luminescence and zonation, (3) Coarsely crystalline sparry calcite cement, dull luminescence, burial origin cement. (B) Same area in ppl.

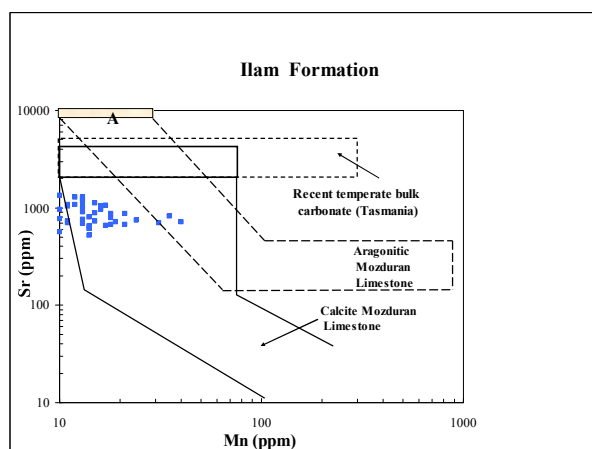


Fig. 3. Sr/Mn quantities in Payun samples. Carbonate samples compared with Recent temperate bulk carbonate(Tasmania)(Rao and Adabi, 1992; Rao and Jayawardane, 1994, Rao and Amini, 1995), Aragonitic Mozduran Limestone(Adabi and Rao, 1991), Calcite Mozduran Limestone(Adabi and Rao, 1996). Note Payun samples falls within calcite Mozduran Limestone and aragonitic Mozduran Limestone. Therefore mixed calcite and aragonite were the original mineralogy of Ilam Formation in Payun Section.

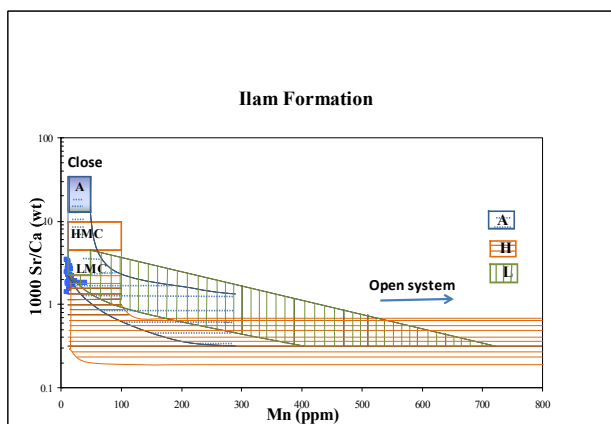


Fig. 4. Mn vs. Sr/Ca, In this diagram, Ilam carbonates samples were affected by semi-closed to open diagenetic system.

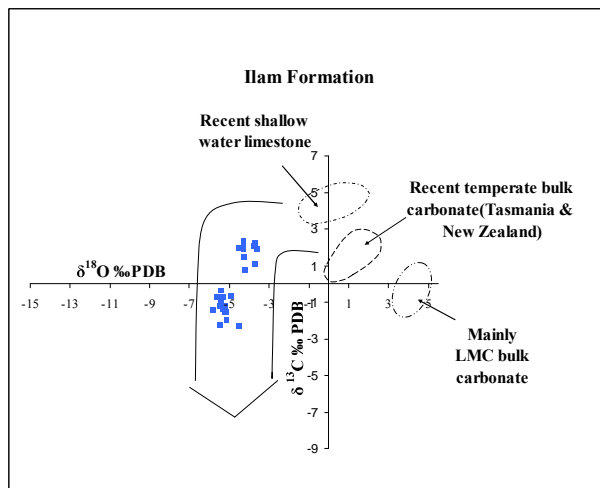


Fig. 5. Comparison of $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values of the Ilam carbonates with recent polar bulk carbonates (Adabi, 1996), recent temperate bulk carbonates (Rao and Adabi, 1992), recent shallow water limestone (Milliman, 1974). Inverted J trend in Ilam Carbonate indicate that this samples influenced by meteoric diagenesis system.

Reference

- 1 - Adabi, M.H., 1996, Sedimentology and geochemistry of Upper Jurassic(Iran) and Precambrian (Tasmania) carbonates: Unpublished Ph.D. Thesis, University of Tasmania, Australia, 407 p.
- 2 - Adabi, M.H., 2004, A re-evaluation of aragonite versus calcite seas: Carbonates and Evaporites v. 19, p. 133–141.
- 3 - Adabi, M.H., Rao, C.P., 1991, Petrographic and geochemical evidence for original aragonitic mineralogy of Upper Jurassic carbonates (Mozduran Formation), Sarakhs area: Iran. Sedimentary Geology, v. 72, p. 253–267.
- 4 - Adabi, M.H., and Rao, C.P., 1996, Petrographic elemental and isotopic criteria for the recognition of carbonate mineralogy and climates during the Jurassic (e.g., from Iran and England): 13th Geol. Conv. Australia, (abst.), p. 6.
- 5 - Adabi, M.H., and Asadi Mehmandosti, E., 2008, Microfacies and geochemistry of the Ilam Formation in the Tang-E Rashid area, Izeh, S.W. Iran”: Journal of Asian Earth Sciences, In press.
- 6 - Dickson, J.A.D., 1965, A modified staining technique for carbonates in thin section: Nature, v. 205, 587p.
- 7 – <http://maps.google.com>
- 8 - Kinsman, D.J.J., Holland, H.D., 1969, The co-precipitation of cations with CaCO_3 . The co-precipitation of Sr^{2+} with aragonite between 16 and 96 °C: Geochimica et Cosmochimica Acta, v. 33, p. 1–17.
- 9 - Milliman, J.D., 1974, Marine Carbonates: New York, Springer-Verlag, 375 p.
- 10 - Nelson, C.S., 1988, An introductory perspective on non-tropical shelf carbonates: Sedimentary Geology, v. 60, p. 3–12.

- 11 - Rao, C.P., and Adabi, M.H., 1992, Carbonate minerals, major and minor elements and oxygen and carbon isotopes and their variation with water depth in cool, temperate carbonates, western Tasmania, Australia: *Mar. Geology*, v. 103, p. 249-272.
- 12 - Rao, C.P., and Jayawardane, M.P.J., 1994, Major minerals, elemental and isotopic composition in modern temperate shelf carbonates, eastern Tasmania, Australia: implications for the occurrence of extensive ancient non-tropical carbonates: *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, v. 107, p.49-63.
- 13 - Rao, C.P., and Amini, Z.Z., 1995, Faunal relationship to grain-size, mineralogy and geochemistry in Recent temperate shelf carbonates, western Tasmania, Australia: *Carbonates and Evaporites*, v. 10, p. 114-123.
- 14 - Wefer, G. and Berger, W.H., 1991, Isotope paleontology: growth and composition of extent calcareous species: *Mar. Geology*, v. 100, p. 207-248.