[PS]Characteristics of Middle Permian Chihsia Dolomite in Western Sichuan Basin, China: A Case Study of Hydrothermal Dolomitization*

Jie Lu[1], Huang Sijing[1], and Huang KeKe[1]

Search and Discovery Article #50659 (2012)**
Posted July 23, 2012

*Adapted from poster presentation at AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012

[1]Chengdu University of Technology, Chengdu, China (lvjiecdut@live.cn)

Abstract

Hydrothermal alteration has become one of the most significant factors in carbonate hydrocarbon reservoir development. The study of dolomite of the Middle Permian Chihsia Formation in Western Sichuan Basin sheds new light on the mechanism of hydrothermal dolomitization, and would provide dolomite research with a Chinese case study. In Chihsia carbonates, preexisting sedimentary fabrics have been strongly and patchily overprinted by medium- to coarse-grained crystalline dolomite phases. Therefore, the dolomitic limestones or calcareous dolomites are the dominant rock types in outcrop and hand specimen scale. The dolomitized parts contain planar and non-planar crystalline dolomite phases, and occur with authigenic minerals (illite, fluorite, quartz, pyrite and fluorapatite). The macro- and micro-petrographic studies of the dolomitized facies and microthermometric analysis of fluid inclusions have revealed the presence of four major dolomite phases and one post-dolomitization calcite phase. The first dolomite phase of small and euhedral to subhedral crystals is volumetrically minor and has the lowest homogenization temperature (Th) range in dolomitizing paragenetic sequence (89°C to 109°C). The following dolomite phase grows on the precursor dolomite crystal, and always occurs as the clear rim of a cloudy dolomite core. The clear dolomite rims have higher Th values than the core parts. The third and non-planar dolomite phase plays a very important role in Chihsia Formation, and contains the fluid inclusions with average Th of 140°C. The fourth dolomite phase often occurs as void-filling dolomite cements, and consists of characteristic saddle dolomite cements that contain fluid inclusions with average Th of 151°C (the maximum is 243°C). A lower temperature calcite phase fills some voids and replaces some dolomite cements, indicating a temperature drop in diagenetic system. The relationship between stylolites and dolomites suggests that the dolomitization event occurred in the shallow burial environment (less than 1,000 m). The geochemical analysis indicates that the dolomitizing fluid was a combination of heated marine-derived water and possibly a modicum of extraneous hydrothermal fluid. On the basis of existing evidences in this study, we propose that the dolomitizing mechanism of Chihsia Formation in Western Sichuan Basin has some connections with ELIP (Emeishan Large Igneous Province) associated thermal events.

油气藏地质及开发工程国家重点实验室
STATE KEY LABORATORY OF OIL AND GAS RESERVOIR GEOLOGY AND EXPLOITATION

Characteristics of Middle Permian Chihsia dolomite in western Sichuan Basin, China: A case study of hydrothermal dolomitization

LU Jie [1,2] HUANG Sijing [1,3] HUANG Keke [1,3]

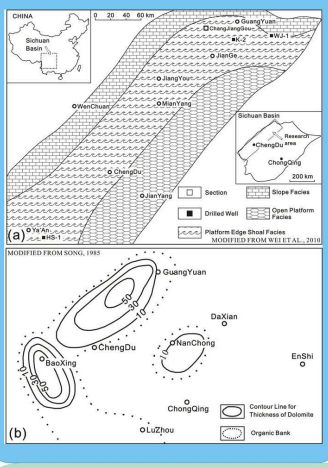
1) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu, Sichuan, China

2) College of Earth Science, Chengdu University of Technology, Chengdu, Sichuan, China

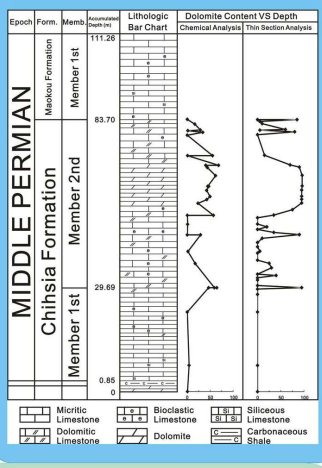
3) Institute of Sedimentary Geology, Chengdu University of Technology, Chengdu, Sichuan, China

Hydrothermal alteration has become one of the most significant factors in carbonate hydrocarbon reservoir development. The study of dolomite of the Middle Permian Chihsia Formation in Western Sichuan Basin sheds new light on the mechanism of hydrothermal dolomitization, and would provide the dolomite research with a Chinese case study. In Chihsia carbonates, preexisting sedimentary fabrics have been strongly and patchily overprinted by medium- to coarse-grained crystalline dolomite phases. Therefore the dolomitic limestones or calcareous dolomites are the dominant rock types in outcrop and hand specimen scale. The dolomitized parts contain planar and non-planar crystalline dolomite phases, and occur with authigenic minerals (illite, fluorite, quartz, pyrite and fluorapatite). The macro- and micro-petrographic studies of the dolomitized facies and microthermometric analysis of fluid inclusions have revealed the presence of four major dolomite phases and one post-dolomitization calcite phase. The first dolomite phase of small and euhedral to subhedral crystals is volumetrically minor and has the lowest homogenization temperature (Th) range in dolomitizing paragenetic sequence (89 to 109°C). The following dolomite phase grows on the precursor dolomite crystal, and always occurs as the clear rim of a cloudy dolomite core. The clear dolomite rims have higher Th values than the core parts. The third and non-planar dolomite phase plays a very important role in Chihsia Formation, and contains the fluid inclusions with average Th of 140°C. The fourth dolomite phase often occurs as void-filling dolomite cements, and consists of characteristic saddle dolomite cements that contain fluid inclusions with average Th of 151°C(The maximum is 243°C). A lower temperature calcite phase fills some voids and replaces some dolomite cements, indicating a temperature drop in diagenetic system. The relationship between stylolites and dolomites suggests that the dolomitization event occurred in the shallow burial environment (less than 1000m). The geochemical analysis indicates that the dolomitizing fluid was a combination of heated marine-derived water and possibly a modicum of extraneous hydrothermal fluid. On the basis of existing evidences in this study, we propose that the dolomitizing mechanism of Chihsia Formation in Western Sichuan Basin has some connections with ELIP (Emeishan Large Igneous Province) associated thermal events.

GENERAL MAP OF THE WESTERN SICHUAN BASIN. AND SIMPLIFIED REGIONAL DISTRIBUTION OF DOLOMITES IN SICHUAN BASIN



GENERALIZED STRATIGRAPHIC COLUMN FOR THE CHIHSIA FORMATION OF CHANGJIANGGOU SECTION



OUTCROP & DRILLING-CORES

Fine to medium crystalline dolomite rock,Changjianggou section, Chihsia Formation, 2nd Member, 160m

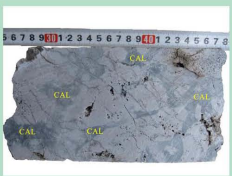
Medium to coarse crystalline (sucrosic) dolomite rock, Changjianggou section, Chihsia Formation, 2nd Member, 161m

Dolomitic limestone or calcite dolomite ("LEOPARD" dolomite/limestone),Changjianggou section, Chihsia Formation, 2nd Member, 177m

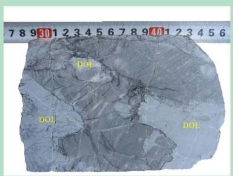
Coarse to extremely coarse crystalline dolomite, Well K-2, Chihsia Formation, 2nd Member, 2414.95-2415.04m

Medium to coarse crystalline dolomite, developing the vug of several centimeters and pore-lining dolomite cements, Well HS-1, Chihsia Formation, 4972.19-4972.29m

Medium to coarse crystalline dolomite, developing the pores of millimeters to several centimeters and pore-lining dolomite cements, Well K-2, Chihsia Formation, 2448.95-2449.17m



Calcite dolomite rock, the calcite parts (CAL) are patchy and blocky, vugs and pores develop in dolomite parts, Well K-2, Chihsia Formation, 2415.68-2415.90m



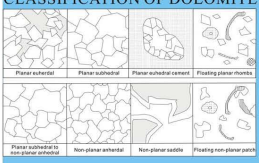
Dolomitic limestone, the dolomite parts (DOL) are patchy and blocky, stylolites develop between dolomite and limestone parts, Well K-2, Chihsia Formation, 2406.50-2406.63m

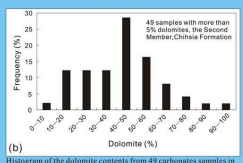
Dolomitic limestone, the dolomite parts (DOL) are patchy and blocky, Changjianggou section, Chihsia Formation, 72.75m

SKL 油气藏地质及开发工程国家重点实验室
STATE KEY LABORATORY OF OIL AND GAS RESERVOIR GEOLOGY AND EXPLOITATION

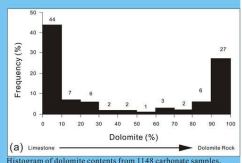
PETROGRAPHY

CLASSIFICATION OF DOLOMITE





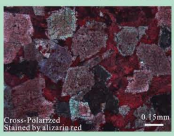
Histogram of the dolomite contents from 49 carbonates samples in Chihsia Formation (this study).



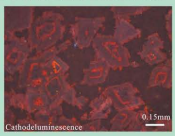
Histogram of dolomite contents from 1148 carbonate samples, North America. Data was from Steidtmann (1926) and Blatt (1992).

PLANAR DOLOMITE FABRICS

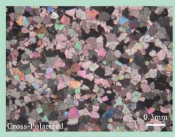
Floating planar dolomite rhombs
with non-dolomitized bioclast



Floating planar dolomite rhombs
with non-dolomitized lime matrix

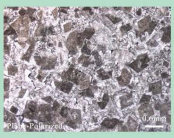


Floating planar dolomite rhombs
with non-dolomitized lime matrix

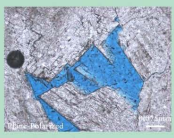


Planar subhedral dolomite crystals
with fine crystal sizes

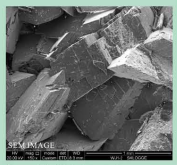
Planar subhedral dolomite crystals
with fine to medium crystal sizes



Dolomite overgrowth parts
with planar euhedral dolomite precursors

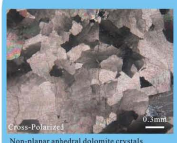


Planar euhderal dolomite cements
develop in pore space
(Blue epoxy casted thin section)

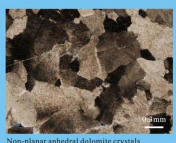


Planar euhderal dolomite cements
develop in pore space

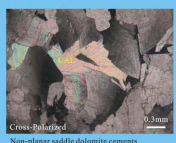
NON-PLANAR DOLOMITE FABRICS



Non-planar anhedral dolomite crystals
with medium to coarse crystal sizes
Showing undulose extinction



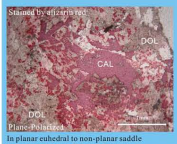
Non-planar anhedral dolomite crystals
with coarse crystal sizes
Showing undulose extinction



Non-planar saddle dolomite cements
with coarse crystal sizes
Showing undulose extinction
and curved crystal faces

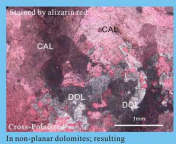
Non-planar saddle dolomite cements
with coarse crystal sizes
Showing undulose extinction
and curved crystal faces

DEDOLOMITE FABRICS

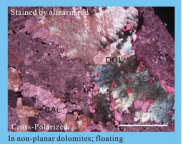


In planar euhedral to non-planar saddle
dolomite cements; floating dolomite
patches in calcite spar

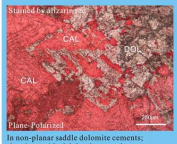
In non-planar saddle dolomites
with fractures; showing calcite with
undulose extinction



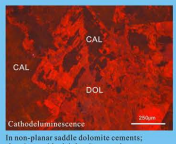
In non-planar dolomites; resulting
the faint crystal boundary of dolomite
and the calcite with undulose extinction



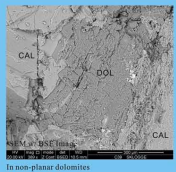
In non-planar dolomites; floating
calcite patches in dolomite crystal



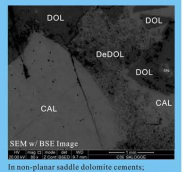
In non-planar saddle dolomite cements;
showing residual dolomite growth zones



In non-planar saddle dolomite cements;
showing residual dolomite growth zones

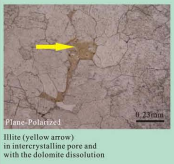


In non-planar dolomites

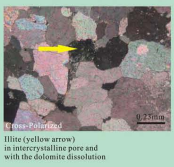


In non-planar saddle dolomite cements;
showing dedolomitization of various degrees

AUTHIGENIC MINERAL



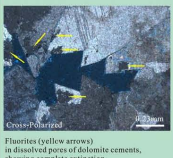
Illite (yellow arrow)
in intercrystalline pore and
with the dolomite dissolution



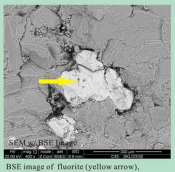
Illite (yellow arrow)
in intercrystalline pore and
with the dolomite dissolution

Fibrous illite
with lots of unknown materials
in intercrystalline pore

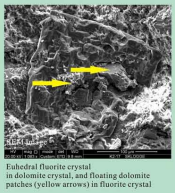
Fibrous illite
with lots of unknown materials
in intercrystalline pore



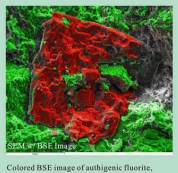
Fluorites (yellow arrows)
in dissolved pores of dolomite cements,
showing complete extinction
under crossed polarized light



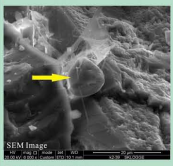
BSE image of fluorite (yellow arrow),
The bright grey part represents fluorite,
and the dark grey part represents dolomite



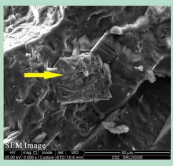
Euhedral fluorite crystal
in dolomite crystal, and floating dolomite
patches (yellow arrows) in fluorite crystal



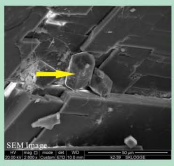
Colored BSE image of authigenic fluorite,
The red part represents fluorite,
and the green part represents dolomite



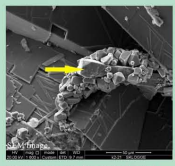
Fluorapatite (yellow arrow)
with fibrous illites, The host dolomite
crystals have the pitted surfaces caused
by dissolution.



Siderite (yellow arrow)
in dissolved intracrystalline pore,
both siderite and host dolomite crystals
have the pitted surfaces caused by dissolution

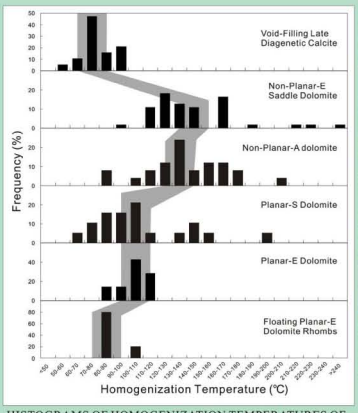


Euhedral quartz crystal (yellow arrow)
with fibrous illites in intercrystalline
pores.

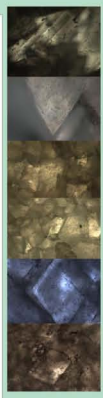


Euhedral pyrite assemblage (yellow arrow)
in intercrystalline pores.

MICROTHERMOMETRY ANALYSIS



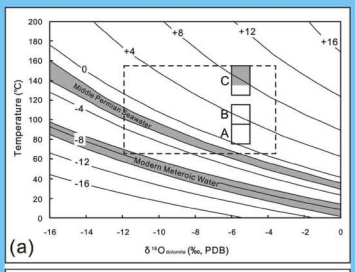
HISTOGRAMS OF HOMOGENIZATION TEMPERATURES OF FLUID INCLUSIONS FROM DIFFERENT CARBONATE PHASES IN CHIHSIA FORMATION, WESTERN SICHUAN BASIN. THE CHANGING TREND OF AVERAGE TH IS MARKED BY THE GREY SHADED AREA.

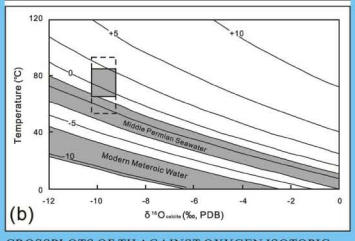


Section /Well	Depth (m)	Host Mineral	Homogenization Temperature (℃) Range	Mean
CJG	32.01	Non-Planar Saddle Dolomite Cement	91 to 223 (3)	160
		Non-Planar-A Dolomite	122 to 203 (7)	157
CJG	39.49	Planar-S Dolomite	67 to 88 (4)	81
		Void-Filling Calcite Cement	78 (1)	78
CJG	48.32	Non-Planar Saddle Dolomite Cement	129 to 170 (4)	149
		Non-Planar-A Dolomite	81 to 166 (10)	137
		Void-Filling Calcite Cement	54 to 76 (4)	69
CJG	54.33	Void-Filling Calcite Cement	81 (1)	81
CJG	58.06	Non-Planar Saddle Dolomite Cement	136 to 158 (5)	146
CJG	59.2	Non-Planar Saddle Dolomite Cement	121 to 243 (4)	156
		Non-Planar-A Dolomite	117 to 173 (2)	145
CJG	60.13	Non-Planar Saddle Dolomite Cement	127 (1)	127
		Non-Planar-A Dolomite	112 to 134 (2)	123
CJG	62.03	Non-Planar-A dolomite	85 to 114 (3)	99
		Planar-S Dolomite	75 to 113 (10)	97
CJG	72.75	Void-Filling Calcite Cement	70 to 93 (6)	80
CJG	82.46	Floating Planar-E Dolomite Rhombs	82 to 102 (5)	89
		Void-Filling Calcite Cement	67 to 93 (6)	80
HS-1	4971.6	Non-Planar Saddle Dolomite Cement	135 to 191 (9)	159
		Planar-E Dolomite Cement	102 to 108 (3)	105
HS-1	4969.23	Non-Planar Saddle Dolomite Cement	125 to 136 (7)	129
		Non-Planar-A Dolomite	130 to 160 (2)	145
		Planar-S Dolomite	139 to 198 (5)	156
K-2	2441.85	Planar-E Dolomite Cement	85 to 115 (4)	103
		Void-Filling Calcite Cement	80 (1)	80
K-2	2426.34	Non-Planar Saddle Dolomite Cement	160 to 195 (10)	174
K-2	2419.81	Non-Planar Saddle Dolomite Cement	157 to 162 (2)	160
		Non-Planar-A Dolomite	147 (1)	147
WI-1	4040.41	Non-Planar Saddle Dolomite Cement	112 to 220 (7)	142
SUMMARY				
Events		Host Mineral	Range of T_h (℃)	Mean of T_h (℃)
MD1		Floating Planar-E Dolomite Rhombs	82 to 102 (5)	89
		Planar-S Dolomite	67 to 198 (19)	109
MD2		Non-Planar-A Dolomite	81 to 203 (25)	140
VD		Non-Planar Saddle Dolomite Cement	91 to 245 (53)	151
		Planar-E Dolomite Cement	85 to 115 (7)	103
LDC		Void-Filling Calcite Cement	54 to 93 (19)	78

SUMMARY OF FLUID-INCLUSION MICROTHERMOMETRIC DATA

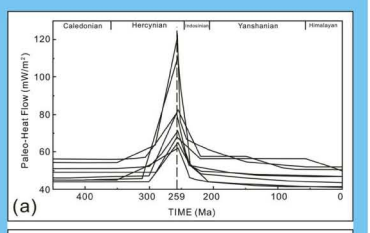
GEOCHEMISTRY & BURIAL HISTORY

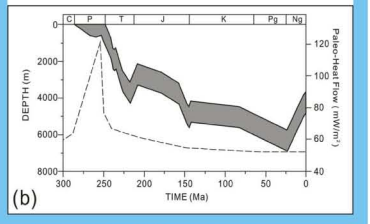




CROSSPLOTS OF TH AGAINST OXYGEN ISOTOPIC SIGNATURE FOR DOLOMITES (a) AND CALCITES (b) IN CHIHSIA FORMATION, WESTERN SICHUAN BASIN.

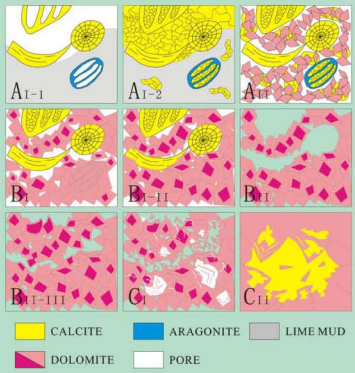
In figure (a), The dash-lined area is composed by δ18O values of all bulk samples and mean Th values of all dolomite phases. Box A represents the floating planar-euhedral dolomite rhombs. Box B represents the planar dolomite phases. Box C represents the non-planar dolomite phases. The shaded area in box C represents saddle dolomites.
In figure (b), The dash-lined area is composed by calculated δ18O value and all Th values of late diagenetic calcite. The grey shaded box area is composed by the calculated δ18O value and mean Th values of late diagenetic calcite.

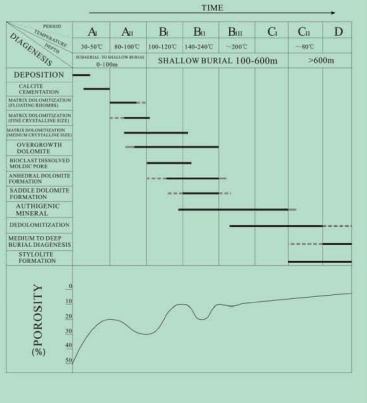




(a) HEAT FLOW HISTORY RECONSTRUCTED FROM DIFFERENT BOREHOLES IN THE SICHUAN BASIN. MODIFIED FROM ZHU ET AL. (2010). (b) BURIAL HISTORY (GREY SHADED AREA) - PALEO-HEAT FLOW (DASHED LINE) PLOT FOR BOREHOLE IN WESTERN SICHUAN BASIN. MODIFIED FROM ZHU ET AL. (2009, 2010).

PARAGENESIS OF DOLOMITIZATION





THIS RESEARCH IS FUND BY NSFC40839908&41172099