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Hydrothermal dolomite—a product of poor definition and imagination

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Abstract

The latest dolomite bandwagon is the "hydrothermal dolomite model". In its present form, this bandwagon is doomed or at least very much overstated for at least two reasons: (1) there are several definitions of hydrothermal, and hardly any author specifies which one s/he is using; (2) very few of the dolomites hitherto called hydrothermal have been demonstrated to be hydrothermal according to any definition, except the worst. As presently applied, the term "hydrothermal dolomite" is confusing and/or meaningless.

We suggest to use White's [Geol. Soc. Amer. Bull. 68 (1957) 1637] time-honored definition of "hydrothermal" as "aqueous solutions that are warm or hot relative to its surrounding environment", with no genetic implications regarding the fluid source. Hence, a dolomite should be called hydrothermal only if it can be demonstrated to have formed at a higher than ambient temperature, regardless of fluid source or drive. Furthermore, this definition does not carry a lower or upper temperature limit. Even a dolomite formed at 40 °C could be hydrothermal. By extension, dolomites formed at temperatures lower than ambient are not hydrothermal, even if they formed at a rather high temperature. For example, groundwater may penetrate a rock sequence through a highly permeable pathway, such that it is heated to 150 °C at a depth where the surrounding rock has a temperature of 250 °C. We suggest to call dolomite formed from this water "hydrofrigid". Dolomite formed in or near thermal equilibrium with the surrounding rocks may be called "geothermal". Furthermore, not all saddle dolomite formation requires advection (fluid flow) to transport Mg. Saddle dolomite can be formed in at least three ways, i.e., from advection, local redistribution of older dolomite during stylolitization, and as a by-product of thermochemical sulfate reduction in a closed or semi-closed system. Only the first and the last of these three possibilities have a chance of being hydrothermal.

Almost all dolomites and dolostones in the Western Canada Sedimentary Basin have recently been (re-)interpreted as hydrothermal. Applying the rationale outlined above reveals, however, that this basin contains very little hydrothermal dolomite. Rather, most dolomites in this basin, and almost all dolostones south of the Peace River Arch, are geothermal, and/or the proof of a hydrothermal origin has not been made. This has important implications beyond the various case studies at hand, as attempts to tie dolomitization to orogenic events become moot, at least in the southern part of the basin.

Keywords: Hydrothermal; Dolomite; Dolostones

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1. Introduction

Dolomite occurs in many diagenetic environments that range from the surface to deep subsurface settings of several kilometers burial depth. Most dolostones originate by the replacement of limestones that form(ed) in shallow-marine environments with normal seawater salinity, which is shown by relics of primary sedimentary features, such as ripple marks, reef fossils, burrows, etc., that have survived the replacement process. In the Recent, however, dolomite is almost absent from such carbonate depositional environments, despite the fact that seawater is many times supersaturated with respect to dolomite. Thus, various models of dolomitization have been devised to explain the origin of these types of replacement dolostones, and almost every time a new model has been proposed, it became a bandwagon until the next popular model arose. There also are dolostones that are devoid of primary sedimentary features, and where an origin without a limestone precursor appears possible. Dolomite is also common, albeit generally not abundant, as a cement in limestones and clastic rocks.

The potential of natural environments to form dolomite and dolostone can be assessed on the basis of the above chemical considerations, and using hundreds of case studies that have been published over the last five decades (see compilations in Zenger et al., 1980; Shukla and Baker, 1988; Purser et al., 1994). Genetically, all natural dolomites can be grouped into two families (Budd, 1997). *Penecontemporaneous dolomites* form while the host sediments are in their original depositional setting. Most known penecontemporaneous dolomites are of Holocene age. However, there probably are many older examples in the geologic record, yet they are much more difficult to prove. *Postdepositional dolomites* form after deposition has ceased and the host carbonates have been removed from the zone of active sedimentation by progradation of the depositional interface, burial, uplift, eustatic sea level change, or any combination of these factors. Almost all dolostones are postdepositional. These dolostones are the subject of this paper.

We shall take the Devonian dolomites and dolostones of western Canada as one, and perhaps the most striking, example of the problem at hand. The major arguments advanced in this paper are valid not only for western Canada but also globally.

2. Hydrothermal dolomitization—the new bandwagon

The Devonian section of the Western Canada Sedimentary Basin (WCSB) contains huge amounts of dolostones (mainly matrix-replacive dolomites, minor dolomite cements), which comprise about 90% of the Devonian carbonates and have been the subject of intense study for more than 40 years. Literally all the bandwagons of dolomitization that came and went over the last four decades have been applied to these dolostones. For example, the compaction model, the freshwater–seawater mixing model, and the sabkha/reflux model all have been invoked yet proven incapable of forming these dolostones. The WCSB contains a few examples of dolomite and dolostone formed by each of these types of dolomitization. However, most dolostones—about 85–90 vol.% of all dolostones south of the Peace River Arch (which separates the WCSB into a smaller northern and a larger southern part)—demonstrably did not form in these ways. The main argument against these models is mass balance. None of the above models can account for the amounts of Mg needed to form the huge quantities of dolomite present (Machel and Mountjoy, 1987, 1990; Machel et al., 1996, 2002; Jones et al., submitted for publication), no matter how hard some authors have tried (Shields and Brady, 1995; Potma et al., 2001). Furthermore, the geochemical composition of most dolomites in the WCSB is inconsistent with an origin via the above models, especially with freshwater–seawater mixing and/or brine reflux (e.g., Amthor et al., 1993; Machel et al., 1994; Mountjoy et al., 1999).

The latest dolomite bandwagon to drive through the WCSB is the "hydrothermal dolomite model". This bandwagon (not the model as such—see Morrow, 1998) is based on the assumption that all saddle dolomite, whether cement or replacive, is hydrothermal and can be taken as an unequivocal indicator and/or proxy of hydrothermal activity (Davies, 1997, 2002, and oral presentation at the Diamond Jubilee Convention of the Canadian Society of Petroleum Geologists, Calgary, June 3–7 2002). This assumption has led to a regional, basin-wide survey for saddle dolomite occurrences, their interpretation as proxy for basin-wide hydrothermal activity, and to the even further reaching inference that basin-wide hydrothermal activity either formed or ''overprinted'' the much more common matrix-replacive dolostones in the basin (Davies, 1997; Reimer et al., 2001). Another proponent of the hydrothermal bandwagon bases his interpretation of basin-wide hydrothermal dolomitization mainly on one case study of possible/likely (but in our opinion not representative) hydrothermal dolomitization in the Keg River Formation (Spencer, 2002). Hence, according to the new bandwagon nearly all dolomites and dolostones in the WCSB are either hydrothermal products or ''overprinted'' by hydrothermal activity. This contrasts sharply with previous interpretations of the saddle dolomites and matrix-replacive dolostones in this basin, whereby only some of the saddle dolomites are hydrothermal, and the matrix-replacive dolostones are not hydrothermal in origin and not ''overprinted'' hydrothermally (e.g., Machel and Mountjoy, 1987; Amthor et al., 1993; Mountjoy et al., 1999).

We contend that the new hydrothermal dolomite bandwagon, as presently applied and invoked in the WCSB (Davies, 1997, 2002), is doomed like the older bandwagons—or at least very much overstated in its significance. Firstly, the term ''hydrothermal'' has at least three, partially contradictory definitions. The term ''hydrothermal dolomite'', as presently applied by the proponents of the bandwagon in the WCSB (and also elsewhere), conforms to the worst of these definitions, which renders the term confusing and/or meaningless. Secondly, not all saddle dolomite is hydrothermal, using any definition. Thirdly, there are at least three ways in which saddle dolomite can be formed. And lastly, like the older bandwagons, the hydrothermal model falls short in delivering the masses of Mg needed to account for all the dolomites and dolostones in the WCSB. Hydrothermal convection cells, required for massive dolomitization, become established and effective only in the absence of effective aquitards (or such cells are restricted to strata between effective aquitards), and/or they require magmatic heat sources (see Wilson et al., 1990; Morrow, 1998, and references cited therein). These aspects of the hydrothermal model appear to be neglected by several proponents of the hydrothermal dolomite bandwagon.

3. Previous definitions of "hydrothermal"

The word ''hydrothermal'' was originally applied to hot waters and mineralization associated with magmatism (Gilbert, 1875; Morey and Niggli, 1913; Holmes, 1928; Stearns et al., 1935). White (1957), recognizing a broader applicability and common usage at the time, defined the term ''hydrothermal'' as ''*aqueous solutions that are warm or hot relative to the surrounding environment*'', with the explicit qualifier that there are no genetic implications regarding the fluid source. The term hydrothermal thus became applicable to nonmagmatic systems, including diagenetic systems conducive to dolomitization. White's (1957) definition has become a time-honored convention. Accordingly, to be called hydrothermal a mineral must be proven to have formed at a temperature significantly higher than that of the surrounding rock(s), whereby 5 to 10 °C is considered significant (Stearns et al., 1935), and whatever the source or driving mechanism of the fluid(s). Hence, the temperature of dolomite formation must be determined (e.g., via isotope and/or fluid inclusion data) and then compared to the temperature of the surrounding rocks at the time of dolomitization, as indicated by independent data (e.g., fluid inclusion data in silicates or other carbonates, vitrinite reflectance data, reconstruction of maximum burial and geothermal gradient, etc.).

The AGI (1999) Glossary of Geology defines ''hydrothermal'' in the context of hydrothermal deposits as ''*formed...from aqueous fluids ranging in temperature from 50°C to 700°C but generally below 400°C, and ranging in pressure from 1 to 3 kilobars*''. Furthermore, all uses of hydrothermal, and its combinations with other words, in the AGI Glossary refer to magmatic and hot ocean vent systems. A recent check of the word hydrothermal in various other glossaries on the Internet revealed the same affinity with magmatic intrusions and systems. Hence, using this definition, in order to be called hydrothermal a dolomite must be proven to be genetically related to a magmatic heat and/or fluid source.

Bodnar (1999, p. 333), in the most recent edition of the Glossary of Geochemistry, defined "hydrothermal" in the following context: "*hydrothermal solutions represent water that has been heated to some temperature above ambient surface temperature as a result of natural geologic processes*". This definition is entirely useless for studies of dolomitization (and probably in general), as it encompasses any and every subsurface fluid, hot or cold relative to its surrounding environment, as long as it is warmer than the surface temperature. Bodnar's (1999) Fig. H7 demonstrates this point, as it is simply a diagram of the hydrologic cycle that includes all types of geologic fluids, including meteoric, seawater, connate, magmatic, metamorphic, and juvenile-mantle water. Hence, using his definition, dolomites formed via brine reflux or compaction dewatering would also be hydrothermal, i.e., all dolomites save those formed directly at the surface at surface temperature would be hydrothermal.

4. Suggested definitions of "hydrothermal" and related terms

For the reasons discussed above, we suggest the continued use of White's (1957) definition, including Stearns et al.'s (1935) rationale for a "significant" temperature difference. In addition, we are introducing two more terms that are useful in this context (Fig. 1).

A mineral should be called "*hydrothermal*" only if it can be demonstrated to have formed at a higher (by >5–10 °C) than ambient temperature, regardless of fluid source or drive (Fig. 1, left). Importantly, this definition does not carry a lower or upper temperature limit. A dolomite formed at only 40 °C could be hydrothermal, if the surrounding rocks were significantly colder than that at the time of dolomite formation.

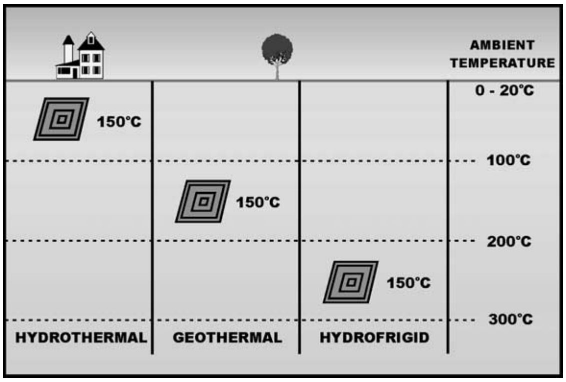

Fig. 1. Hydrothermal, geothermal (formed in thermal equilibrium with the surrounding rocks), and hydrofrigid mineral formation.

If a mineral was formed at or near the same temperature as the surrounding rocks (within 5–10 °C), it should be called "*geothermal*" (Fig. 1, center), whatever the geothermal gradient. In keeping with common usage, the qualifier "geothermal" may simply be omitted, unless special emphasis needs to be placed on the geothermal nature of a particular mineralization event.

Minerals formed at temperatures significantly lower than ambient (by >5–10 °C) may be called "*hydrofrigid*", even if they formed at a rather high temperature (Fig. 1, right). For example, seawater or freshwater may penetrate a rock sequence through highly permeable pathways, such that the water is heated to 150 °C at a depth where the surrounding rock has a temperature of 250 °C. If a mineral were formed at that time from the incompletely heated water, the mineral would be hydrofrigid.

The choice of 150 °C in Fig. 1 for the dolomite formed is not accidental. We chose a temperature high enough for saddle dolomite to form, which is the most common—albeit not the only—textural type of dolomite that forms at temperatures higher than about 80–100 °C (Radke and Mathis, 1980; Machel, 1987). Saddle dolomite has often and indiscriminately been called hydrothermal (e.g., Davies, 1997; Reimer et al., 2001). However, as shown in Fig. 1, saddle dolomite may not be hydrothermal. The presence of saddle dolomite, whatever its temperature of formation, says nothing about the local or regional thermal regime. Rather, the presence of saddle dolomite merely indicates a temperature of formation that is relatively high in the context of diagenetic studies. Its presence in uplifted dolomites, or in structurally inverted subsurface systems currently at lower temperatures, may merely reflect processes formerly operating at depths (and temperatures) at or around maximum burial and with normal geothermal gradients.

It is tempting to call saddle dolomite "high-temperature" dolomite. We hesitate to recommend the use of this term, however, as it would be confusing to those who work in metamorphic and igneous-hydrothermal systems, where temperatures much higher than 100 °C are considered "cool". Furthermore, Davies (2002) recently renamed hydrothermal dolomite "thermobaric dolomite". While we acknowledge the usefulness to consider the role of pressure in the formation of dolomite at elevated temperatures (especially in the context of fluids rapidly escaping upwards through faults), we do not recommend to use the new term "thermobaric". This term does not remove the key problem at hand, which is that saddle dolomite cannot be taken as a simple proxy for elevated heat flow, and that the temperature of dolomite formation must be compared to the ambient temperature for an assessment of hydrothermal activity.

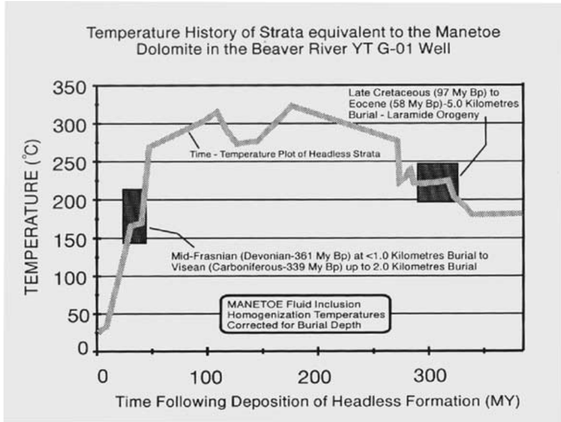

Fig. 3. Hot-temperature, geothermal Manetoe dolomite facies. Figure reproduced with permission from Morrow and Aulstead (1995).

5. Which dolomites and dolostones in the WCSB are hydrothermal?

In the WCSB, there are large, regionally extensive bodies of saddle dolomite north of the Peace River Arch, in a region long known for its history of regionally elevated heat flow (e.g., Mossop and Shetsen, 1994). Saddle dolomite is indeed fairly common in the northern part of the WCSB, the probably best known example being the Presqu'ile saddle dolomite facies that also contains MVT-type lead–zinc mineralization at Pine Point (Qing and Mountjoy, 1992, 1994). The average temperatures of formation for the Presqu'ile dolomites range from 154–178 (190) °C in British Columbia, via 112–144 (130–160) °C in the N.W.T., to 92–106 (106) °C at Pine Point (along the paleoflow path), whereby the ranges listed above are raw ranges of fluid inclusion homogenization temperatures, with pressure-corrected numbers in parentheses. By comparison, the maximum temperatures of the wall rocks range from 143–160 °C in BC, via 90–143 °C in the N.W.T., to 66 °C at Pine Point, respectively (Fig. 2; note: the maximum temperature at Pine Point is confirmed by vitrinite reflectance data). The data therefore show that the Presqu'ile saddle dolomite facies originated from regional hydrothermal fluid flow.

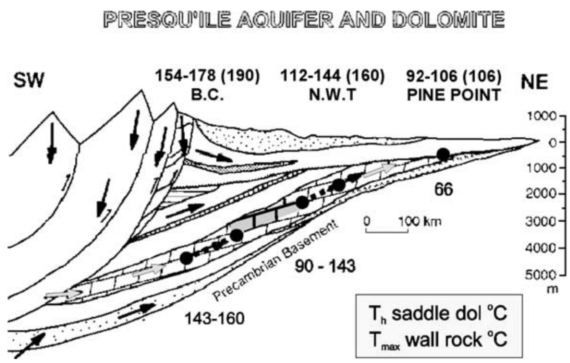

Fig. 2. Hydrothermal Presqu'ile saddle dolomite aquifer. Figure is modified from Qing and Mountjoy (1992, 1994).

Another possible example of hydrothermal dolomite is the Manetoe saddle dolomite facies that may or may not be genetically linked to the Presqu'ile (e.g., Morrow and Aulstead, 1995). However, the Manetoe could also be geothermal or even hydrofrigid, notwithstanding the fact that it formed at temperatures around 200 °C. There is no doubt that the Manetoe facies is a high-temperature diagenetic mineralization event, and we think that Morrow and Aulstead (1995) interpreted the genesis of the Manetoe dolomite facies correctly. However, their label of the Manetoe as "hydrothermal" is incorrect, as implied by their own rationale. Morrow and Aulstead (1995) fitted the fluid inclusion data to the calculated burial curve (Fig. 3), deeming it unlikely that the saddle dolomites formed in thermal disequilibrium of about 100 °C with the surrounding rocks (the maximum temperature of which exceeded 300 °C), thereby "making" this dolomite facies geothermal. Yet, in their Conclusions (p. 279) they state: “The Manetoe dolomite is one, and perhaps the volumetrically largest, example of hydrothermal-type white dolomite that formed in the subsurface at shallow depths in Late Devonian to Carboniferous time”.

A clear and in several ways representative case of geothermal dolomitization is the Nisku Formation in the West Pembina area, which is located in the southern part of the WCSB, i.e., south of the Peace River Arch. The southern part of the WCSB does not have a history of regionally elevated heat flow but has had near-normal geothermal gradients since the late Paleozoic, except for a few, small locations where relatively hot fluids appear to have ascended via faults and fractures (Mossop and Shetsen, 1994; Stasiuk et al., 2002). The West Pembina area is not one of these locations. The matrix-replacive dolostones (about 95% of the Nisku dolomites) formed during burial at about 500–1500 m from circulating seawater, whereas the Nisku saddle dolomites (about 5% of all Nisku dolomites) formed as a combination of pressure solution and thermochemical sulfate reduction at temperatures around 140–160 °C (Machel, 1987; Machel and Anderson, 1989; Machel et al., 1995). Both types of dolomite in the Nisku are geothermal. They are not hydrothermal or hydrothermally “overprinted”, as claimed by Davies (1997), which is precluded by a multitude of geochemical data (e.g., Machel, 1987; Machel and Anderson, 1989; Machel et al., 1995).

More generally, an overview of the dolomites in the WCSB south of the Peace River Arch reveals that only about 5–10% of all dolomites are saddle dolomites, which are mostly white, coarse-crystalline cements in vugs, whereas the bulk of the dolomites are fine- to medium crystalline matrix-replacive dolostones, which make up about 85–95% of all Devonian carbonates (e.g., Machel and Mountjoy, 1987). The bandwagon of hydrothermal dolomitization is going strong even in this part of the basin, where it has been applied to both saddle dolomites and the much more common matrix-replacive dolostones. Davies (1997, p. 59) asserted that an “HTD (hydrothermal dolomite) overprint in Devonian carbonates in Alberta... often attributed to burial ‘matrix’ processes may be the product of hydrothermal fluid migration”. This assertion, based again on the assumption that all saddle dolomites are hydrothermal, and that their emplacement may have affected also the limestones and older dolomites, is tenuous at best, and demonstrably wrong for most dolomites in the southern WCSB. There is no credible evidence for most of these dolomites being hydrothermal in origin and/or having a hydrothermal “overprint”, except for isolated cases of probable hydrothermal dolomites, such as in the Wabamun Group and in the Keg River Formation, which are in the upper and in the lower of the four stratigraphic levels of the Devonian, respectively. Packard and Al-Aasm (2002) unwittingly made this (our) point in their recent presentation at the Diamond Jubilee Convention of the Canadian Society of Petroleum Geologists, where they spoke as proponents of the hydrothermal bandwagon. They made an eloquent argument in favor of a hydrothermal origin of a series of saddle dolomite occurrences in the Wabamun Group along the western edge of the basin, i.e., in the deepest part of the basin next to the deformation front of the Rocky Mountains, where there are indications of island arc volcanic activity during the Devonian Antler orogeny. On the other hand, they also showed that the Wabamun Group in the central and southeastern part of the basin consists almost exclusively of geothermal dolostones that originated from relatively cold seawater circulation. The hydrothermal locations discussed by these authors make up less than 0.5% of all the dolomite in the Wabamun, and they appear like pimples on a map compared to the estimated 290 billion metric tons of geothermal dolostones covering an area of at least 188,000 km^2 (these numbers are cited from Packard and Al-Aasm, 2002). Hence, these authors affirmed our previous conclusion that almost none of the Devonian dolomites and dolostones in the WCSB south of the Peace River Arch are geothermal, whether they are saddle dolomites or matrix-replacive dolostones.

It should also be kept in mind that the Devonian section and the overlying strata in the southern WCSB contain several thick, regionally extensive aquitards. They preclude the establishment of large-scale hydrothermal convection cells capable of pervasive dolomitization under normal geothermal gradients. In addition, there are no igneous intrusions capable of driving hydrothermal convection cells of the magnitude shown by Wilson et al. (1990) that postdate the deposition of the Devonian section. In other words, regional-scale hydrothermal convection capable of pervasive dolomitization was hydrologically impossible.

As for the origin of the massive amounts of matrix-replacive dolostones in the WCSB, the best interpretation to date suggests that most of them are geothermal and formed at depths between about 500 and 1500 m from chemically slightly altered seawater that was driven though the sediments in some hitherto unknown manner, probably due to a combination of hydrologic drives (e.g., Amthor et al., 1993; Machel et al., 1994; Mountjoy et al., 1999). In addition, there appear to be cases of reflux dolomitization by seawater evaporated to about gypsum saturation, i.e., the Grosmont platform in northeastern Alberta (Jones et al., 2002) and probably/possibly the Wabamun in southeastern Alberta (Packard and Al-Aasm, 2002). One could argue that in both cases it was large-scale convection of (chemically altered) seawater that accomplished pervasive replacive dolomitization.

On the other hand, the formation of most saddle dolomites did not require any flow other than over short distances and intra-formationally, i.e., there was no requirement for advection. Rather, many/most saddle dolomites were precipitated as cements in vugs in the vicinity of stylolites, and they originated from the local redistribution of matrix dolomites via pressure solution during burial, as indicated by their spatial distribution and isotopic composition. Such saddle dolomite cements are geothermal. In addition, some saddle dolomite clearly formed as a by-product of thermochemical sulfate reduction, as indicated by depleted carbon isotope values (e.g., Machel, 1987; Machel et al., 1995). Thermochemical sulfate reduction commonly takes place in closed or semi-closed systems (Machel, 2001); hence, the amount of these saddle dolomites is very small and limited by the local supply of Mg. Considering further that thermochemical sulfate reduction is not likely to increase the reservoir temperature by more than about 1 °C, if at all (Simpson et al., 1996), even these saddle dolomites are geothermal. Only some saddle dolomite occurrences, such as the examples discussed by Packard and Al-Aasm (2002), appear to be truly hydrothermal and formed from hot fluids that ascended along faults.

At this time, we do not know of any unequivocal cases of hydrofrigid dolomites in the WCSB, although there are several possible candidates. Reimer and Teare (1992) and Reimer et al. (2001) proposed that breccias cemented with saddle dolomite encased in limestone formed in a so-called "hydrothermal dolomite furnace" (HTD-furnace), and that thermochemical sulfate reduction (TSR) initiated and promoted such dolomitization. This "TSR-HTD model" is based partially on the notion that TSR is exothermic (Reimer and Teare, 1992; Reimer et al., 2001). However, we contend that such saddle dolomite bodies are likely to be hydrofrigid where associated with TSR, and that TSR did not initiate such dolomitization. Firstly, it is not justified to assume that all or even most TSR settings are hydrothermal. Simpson et al. (1996) and Simpson (1999) have shown that TSR probably is endothermic in many, if not most, cases. Secondly, most TSR settings are closed or nearly closed hydrodynamically (Machel, 2001), whereas dolomitization requires an open system because of the requirement to deliver Mg. At best, TSR may be coincident with dolomitization in such a setting and add some oxidized carbon to the saddle dolomite. On the other hand, where brecciated dolomite bodies such as those discussed by Reimer and Teare (1992) and Reimer et al. (2001) formed without an involvement of TSR, i.e., caused by fluid flow ascending via faults, the saddle dolomite may well be hydrothermal.

6. Conclusions

Saddle dolomite has often and indiscriminately been called hydrothermal. This use of the word hydrothermal should be abandoned because saddle dolomite may be hydrothermal, geothermal, or hydrofrigid. A distinction between these alternatives can only be made if the temperature of formation of saddle dolomite (or of another mineral) is considered relative to the temperature of the surrounding rocks at the time of saddle dolomite (or other mineral) formation. Failing to do so may lead to a misguided search for elevated heat flow, local or regional and related to fault and fracture systems, or to other tectonic elements including magmatism. Although there is no doubt that many saddle dolomite occurrences are related to faulting, this observations alone does not necessarily imply elevated heat flow and/or hydrothermal activity. Rather, saddle dolomites can be formed in at least three ways, i.e., from advection (fluid flow), local redistribution of older dolomite during stylolitization, and as a by-product of thermochemical sulfate reduction in a closed or semi-closed system. Only the first and the last of these three possibilities have a chance of being hydrothermal.

We are troubled by the recent bandwagon of hydrothermal dolomitization in the Western Canada Sedimentary Basin. There is no doubt that (a) there are quite a number of saddle dolomite occurrences in the basin, especially north of the peace River Arch, (b) that many of these occurrences may be hydrothermal (although a proof has rarely been made), and (c) that many, if not most, of these occurrences are related to faulting, as documented by Davies (1997). In addition, we agree with Davies' (1997, 2002), Reimer (2002) and Spencer's (2002) notion that a thorough structural analysis will aid in finding possible locations of hydrothermal activity related to faulting. However, we disagree with the sweeping generalization, made by Davies (1997, 2002) and (Spencer, 2002), unsupported by credible data, that hydrothermal activity is responsible for the formation of most of the dolomites and dolostones in the WCSB. The available evidence suggests to us that many, if not most, of the saddle dolomite occurrences cited as evidence for hydrothermal activity are, in fact, geothermal, and that all matrix-replacive dolostones are geothermal, albeit of probably at least two hydrologically/geochemically differing origins. We therefore contend that the importance of hydrothermal dolomitization has been vastly overstated, certainly for the southern part of the Western Canada Sedimentary Basin.

Acknowledgements

This article was written in the spring of 2002, the senior author having worried about the hydrothermal dolomite bandwagon for several years. Some parts of this article were added to the original manuscript after the 2002 Diamond Jubilee Convention of the Canadian Society of Petroleum Geologists, Calgary, June 3–7 2002, where a 1-day session of oral presentations was devoted to this subject. Although this session was designed to bolster the case of the proponents of the hydrothermal bandwagon, our points were strengthened rather than weakened. We are very grateful to Graham Davies for inviting HGM to present the counter-arguments to the hydrothermal dolomite bandwagon at that session, although we disagree on some aspects and especially the overall importance of hydrothermal dolomitization. The research that our arguments are based on was financially supported by NSERC. We also acknowledge many fruitful discussions with Eric Mountjoy, Ben Rostron, and Gareth Jones.

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